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# TABLE OF CONTENTS—VOLUME XXXVI

## CONTENTS OF No. 1

	PAGE
DAY, M. F.—The Homologies of the Ring Gland of Diptera Brachycera.....	1
CAUSEY, O. R., DEANE, L. M., DEANE, M. P., and SAMPAIO, M. M.— <i>Anopheles (Nyssorhynchus) sawyeri</i> , a New Anopheline Mosquito from Ceara, Brazil...	11
BATES, MARSTON—Mosquitoes as Vectors of <i>Dermatobia</i> in Eastern Colombia..	21
FOX, HENRY—Further Studies on Oothecae of Introduced Asiatic Mantids (Orthoptera: Mantidae).....	25
KNOLL, J. N.—Two New Chrysobothris (Buprestidae: Coleoptera).....	34
METCALF, ROBERT L.—The Isolation of a Red-Fluorescent Pigment, Lampyrine, from the Lampyridae.....	37
HORSFALL, WILLIAM R.—Some Responses of the Malaria Mosquito to Light...	41
STRANDTMANN, R. W.—Description of Female <i>Ampulex (Rhynopsis) ferruginea</i> Bradley (Hymenoptera: Ampulicidae).....	46
MICHENER, CHARLES D.—The American Bees of the Genus <i>Anthocopa</i> with Notes on Old World Subgenera (Hymenoptera, Megachilidae).....	49
BROWN, F. MARTIN—Notes on Ecuadorian Butterflies. III. The Genus <i>Lymanopoda</i> Westwood (Satyridae).....	87
ALEXANDER, CHARLES P.—New Species of Crane-Flies from South America. Part X. (Tipulidae: Diptera).....	103
WRAY, D. L., AND BRIMLEY, C. S.—The Insect Inquilines and Victims of Pitcher Plants in North Carolina.....	128
Book Notices.....	33, 36, 45, 127, 138-143
Members of the Entomological Society of America Enrolled in the Armed and Related Service of the United States. ....	144
Report of the Thirty-seventh Annual Meeting of the Entomological Society of America .....	147

## CONTENTS OF No. 2

GEIJSKES, D. C.—Notes on Odonata of Surinam. IV. Nine New or Little Known Zygopterous Nymphs from the Inland Waters.....	165
NEEDHAM, JAMES G.—Life History Notes on Micrathyria (Odonata). ....	185
KENNEDY, CLARENCE HAMILTON—A Dragonfly Nymph Design on Indian Pottery.....	190
TOWNSEND, CHARLES H. T.—On the Nyssorhynchus Complex (Diptera: Culicidae).....	192
GURNEY, ASHLEY BUELL—A Synopsis of the Psocids of the Tribe Psyllipsocini, including the Description of an Unusual New Genus from Arizona (Corrodentia: Empheriidae: Empheriinae).....	195
RAU, PHIL—How the Cockroach Deposits Its Egg-Case; a Study of Insect Behavior.....	221
POWER, MAXWELL E., AND MELAMPY, R. M.—Dimorphism in the Female Honeybee ( <i>Apis mellifera</i> L.): Development of the Metathoracic Tibia...	227
FERNALD, H. T.—A New Species of Chlorion from Cuba (Hym. Sphecinae)...	238
DOW, RICHARD—Note on the Male Genitalia of Certain Isodontia (Hym.: Sphecidae).....	240
CROWELL, HAMBLIN H.—Feeding Habits of the Southern Armyworm and Rate of Passage of Food Through its Gut.....	243
LYMAN, F. EARLE—Swimming and Burrowing Activities of Mayfly Nymphs of the Genus <i>Hexagenia</i> .....	250

# TABLE OF CONTENTS—[Continued]

	PAGE
KAGAN, MARTIN—The Araneida Found on Cotton in Central Texas	257
STAINS, G S, AND KNOWLTON, G F—A Taxonomic and Distributional Study of Simuliidae of Western United States	259
PRITCHARD, A EARL—Revision of the Genus <i>Cophura</i> Osten Sacken (Diptera, Asilidae)	281
BRUES, CHARLES T—The American Species of <i>Rhopalosoma</i>	310
WHEELER, GEORGE C—The Larvae of the Army Ants	319
The General Council on Zoological Nomenclature	333
The Foundation for the Study of Cycles	335
Members of the Entomological Society of America Enrolled in the Armed and Related Service of the United States	337
Book Notices	189, 194, 220, 239, 242, 249, 258, 280, 309, 318, 336

## CONTENTS OF No. 3

BOHART, RICHARD M—New Species of <i>Halictophagus</i> with a Key to the Genus in North America (Strepsiptera, Halictophagidae)	341
MACSWAIN, J W—The Primary Larva and Systematic Position of the Meloid Genus <i>Poreospasta</i> (Coleoptera)	360
JAMES, MAURICE T—Studies in Neotropical Stratiomyidae (Diptera) V The Classification of the Raphiocerinae	365
JAMES, MAURICE T—Studies in Neotropical Stratiomyidae (Diptera) VI A New Genus Related to <i>Adoxomyia</i>	380
DEONIFR, CHRISTIAN C—Biology of the Immature Stages of the Clear Lake Gnat (Diptera, Culicidae)	383
NEVIN, F REESE— <i>Caeculus peltis</i> , a New Species of Mite from Virginia	389
BEQUAERT, J C—A New Species of <i>Polybia</i> from Panama (Hymenoptera, Vespidae)	394
ROTH, LOUIS M—Studies on the Gaseous Secretion of <i>Tribolium confusum</i> Duval II The Odoriferous Glands of <i>Tribolium confusum</i>	397
FLUCK, C L—A New Genus and New Species of Syrphidae (Diptera) from Ecuador	425
TOOLLY, TYLER A—The Metamorphosis of the Nervous System of <i>Aedes dorsalis</i> Meigen (Diptera Culicidae)	432
The C V Riley Centennial Exhibition, Museum of National Expansion, St Louis	447
DELONG DWIGHT M—A New Genus— <i>Stoneana</i> —and Three New Species of Mexican Leafhoppers (Homoptera Cicadellidae)	448
KROMBEIN, KARL V A New Philippine <i>Nippononysson</i> with Remarks on the Affinities of the Genus (Hymenoptera Nyssonidae)	451
FUNKHOUSER, W D—Membracidae of Guatemala	455
MOORI, WARREN—Some Vitamin Requirements of Black Carpet Beetles, <i>Attagenus</i> (?) spp (Coleoptera Dermestidae)	483
CHAMBERLIN, JOSEPH C—The Taxonomy of the False Scorpion Genus <i>Symphronus</i> with Remarks on the Sporadic Loss of Stability in Generally Constant Morphological Characters (Arachnida Chelonethida)	486
SABROSKY, CURTIS W—New Genera and Species of Astendae (Diptera), with a Review of the Family in the Americas	501
RAU, PHIL—The Nesting Habits of Mexican Social and Solitary Wasps of the Family Vespidae	515
BLINDER, JOSEPH CHRISTAL—Anatomy and Histology of the Female Reproductive Organs of <i>Habrobracon juglandis</i> (Ashmead), (Hymenoptera, Braconidae)	537
SEEVERS, CHARLES H, AND DYBAS, HENRY S—A Synopsis of the Limulodidae (Coleoptera): A New Family Proposed for Myrmecophiles of the Subfamilies Limulodinae (Ptilidae) and Cephaloplectinae (Staphylinidae)	546
Book Notices	359, 364, 382, 431, 454, 482, 485, 500, 514, 536, 545, 586-588

# TABLE OF CONTENTS—[Continued]

## CONTENTS OF No. 4

	PAGE
LINSLEY, E. G., AND MACSWAIN, J. W.—Observations on the Life History of <i>Trichodes ornatus</i> (Coleoptera, Cleridae), a Larval Predator in the Nests of Bees and Easps.....	589
USINGER, ROBERT L.—A Revised Classification of the Reduvioidae with a New Subfamily from South America (Hemiptera).....	602
PARKER, H. L.—Gross Anatomy of the Larva of the Wasp <i>Polistes gallicus</i> (L.), (Hymenoptera, Vespidae).....	619
SHELL, STEWART C.—The Biology of <i>Hadronotus ajax</i> Girault (Hymenoptera—Scelionidae), a Parasite in the Eggs of Squash-bug ( <i>Anasa tristis</i> DeGeer) ..	625
DAVIDSON, RALPH H., AND DELONG, DWIGHT M.—Studies of the Genus <i>Empoasca</i> (Homoptera, Cicadellidae). Part XI. Six New Species of <i>Empoasca</i> from Mexico.....	636
RAU, PHIL—Notes on the Nesting Habits of Certain Social and Solitary Bees of Mexico.....	641
RAU, PHIL—The Nesting Habits of Certain Sphecid Wasps of Mexico, with Notes on Their Parasites.....	647
DELONG, DWIGHT M.—A New Genus, <i>Artucephalus</i> , and a New Species of Mexican Leafhopper (Homoptera, Cicadellidae).....	654
MITCHELL, THEODORE B.—On the Classification of Neotropical Megachile (Hymenoptera: Megachilidae).....	656
JEERBOWER, FRED V.—Life History of <i>Scirtes orbiculatus</i> Fabius (Coleoptera: Helodidae).....	672
WALKER, E. M.—On the Anatomy of <i>Grylloblatta campodeiformis</i> Walker. 4. Exoskeleton and Musculature of the Abdomen.....	681
FORBES, WM. T. M.—The Genus <i>Thyridia</i> (Lepidoptera, Ithomiinae).....	707
BEQUAERT, J. C.—On the So-called <i>Mischocyttarus ater</i> , <i>Polybia atra</i> , and their Relatives (Hymenoptera, Vespidae).....	717
HUNGATE, R. E.—Quantitative Analyses on the Cellulose Fermentation by Termite Protozoa.....	730
OSBURN, RAYMOND C.—Two Unusual <i>Vespula</i> Nests.....	740
HEADLEY, A. E.—Population Studies of Two Species of Ants, <i>Leptothorax longispinosus</i> Roger and <i>Leptothorax curvispinosus</i> Mayr.....	743
SHEPARD, HAROLD H.—The Types of Hesperoid Genera. Further Additions and Corrections to the Lindsey List, 1925.....	754
JOHANNSEN, O. A.—Two New Species of American Ceratopogonidae (Diptera). 761	
JOHANNSEN, O. A.—A Generic Synopsis of the Ceratopogonidae (Heleidae) of the Americas, A Bibliography, and a List of the North American Species. 763	
Book Notices..... 601, 618, 624, 640, 646, 653, 655, 680, 739, 762, 792-798	
Corrections (Errors and Omissions).....	798
Index to Volume XXXVI.....	799

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## THE HOMOLOGIES OF THE RING GLAND OF DIPTERA BRACHYCERA

M. F. DAY,

Biological Laboratories, Harvard University,  
Cambridge, Mass.

A prerequisite of any theory of the source of insect hormones which attempts to reconcile observations on the Diptera with those on other insects is a knowledge of the homologies of the ring gland. This organ was first described by Weismann in 1864 in his description of the development of *Calliphora vomitoria* L. and *Sarcophaga carnaria* Meig., and has been referred to frequently as "Weismann's Ring." It has since been described many times in various Diptera Brachycera, usually having been considered, following Weismann, a supporting structure of the dorsal vessel. Burt, first (1937)\* from phylogenetic studies of Nematocera and Brachycera and from the morphology of the gland, and later from a physiological investigation (1938) concluded that the ring gland is homologous with the corpus allatum of other insects. Mellanby (1938) accepted this view without question. In 1938 Scharrer and Hadorn suggested that the corpus cardiacum was also included in the ring gland. Hanström (1939), without knowledge of their work, concluded that the ring gland was composed only of corpus cardiacum tissue.

The homologies of the ring gland may be elucidated by several methods: by the study of evidence from comparative morphology and phylogeny; by a determination of the embryonic origin of the constituents of the gland; or from the changes undergone by the gland at metamorphosis. The first method was utilized in reaching the conclusions mentioned above. The third method should indicate definitely the composition of the ring, for there is a typical median corpus allatum present in the adult fly. Such observations are presented in this paper.

### MATERIALS AND METHODS

Most of the observations to be reported were made on the larvae, pupae, and adults of a pure strain of *Lucilia sericata* Meig.,<sup>1</sup> which

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<sup>1</sup>Obtained through the courtesy of Dr. D. F. Miller, Ohio State University, to whom my thanks are due. For a description of this strain, see Miller (1940), *Science*, 92: 147-148.

was maintained in culture at a temperature of  $21 \pm 1^\circ \text{C}$ . The various stages were fixed by injection with Bouin's fluid or formol-sublimate in 0.4% NaCl, followed by Mallory's triple stain, or by the Duboscq-Brasil modification of Bouin's fluid followed by Bodian's protargol technique. Tissues were double embedded in celloidin and paraffin and sectioned at 7 or 10 microns.

## DEVELOPMENT AND MORPHOLOGY OF THE RING GLAND

The ring gland of the full-grown larva will first be described, then its condition in pupae of various ages, and finally the glands of the mature fly.

*I. The Full-grown Larva.*—The ring gland of *Lucilia* has not been previously described, but does not differ in essentials from that of *Calliphora* (Burt, 1937). It is, however, considerably more elongate (fig. 1). The ring is continuous above the aorta anteriorly, and beneath this vessel posteriorly due to its attachment to the hypocerebral ganglion. Nerves arising from the brain just behind the commissure enter the gland at the posterior end. It has not been possible to trace their path through the brain itself, but they probably represent the nervus corporis cardiaci I (NCC I) of Hanström (1940), with nerve cell bodies in the pars intercerebralis. The ring gland also receives nerve fibers from the hypocerebral ganglion, which is situated on the recurrent nerve. Nerve cell bodies, conspicuous by their dense, basophilic cytoplasm, are found scattered throughout the gland, as shown by Burt in *Calliphora*. Nerve fibers may be demonstrated between the gland cells and form a small nerve which runs in the dorsal wall of the incomplete aorta as the latter continues anteriorly from the ring gland.

One of the reasons given by Scharrer and Hadorn for believing that some of the ring gland cells represent corpus cardiacum tissue is the close relationship between this gland and the aorta, a condition characteristic of the corpus cardiacum of many insects. In *Lucilia* the gland is distinctly separated from the aorta except at its dorsal and ventral extremities, and only at the former (fig. 4) is there any sign of "Durchlasszellen" comparable to those described by Pflugfelder (1937) in *Dixippus*. A similar condition has been found in sections of *Drosophila melanogaster* Meig. The aorta in higher Diptera is unusual in running dorsal to the brain, rather than following the gut or terminating behind the brain, as in other insects.

The tracheal supply of the gland is very characteristic (fig. 1A). A pair of large trunks enter from the anterior end of the gland on each side of the aorta, and at the point of entry, these are joined by a connecting trunk which runs entirely within the tissues of the gland. The lateral trunks continue back through the gland, and emerge from it at its posterior end just behind the NCC I. The trunks then enter the brain, and shortly break up into very many tracheoles which run to almost all parts of the supra- and sub-oesophageal ganglia. The epithelium of the trunks is unusual, being far thicker than that of most larval tracheae. The cells composing it are very small and are frequently found in mitosis, indicating that they are imaginal bud cells, as

was shown by Burt in *Calliphora*. Whether the unusual epithelium plays any part in the physiology of the trachea would be difficult to determine.

Histologically the gland is composed of five cell types, though only two of these undergo marked changes during the pupal and adult life of the fly. Giacomini (1900) has recorded small cells at each end of the gland of *Eristalis tenax* L., and Burt (1937) noted nerve cell bodies in the gland of *Calliphora*. Scharrer and Hadorn (1938) record the presence of cells of two distinct sizes of *Drosophila*, and consider that the small cells represent the corpus cardiacum tissue. The greater portion of the gland in the larva of *Lucilia sericata*, that is, the region on each size of the aorta, is composed principally of very large cells (approximately 30 x 40 microns), with finely granular, relatively acidophilic cytoplasm. The nucleus is large (approximately 15 microns in diameter) and poor in chromatin, while the chromosomes appear to be in the "polytene" condition, characteristic of some insect gland cells. The cytoplasm of these cells shows no inclusions with the methods employed. The nerve cell bodies, scattered between the large secretory cells, have been referred to above. The small cells at the posterior end mentioned by Giacomini, are associated in *Lucilia* with nervous tissue, since the gland is closely connected with the hypocerebral ganglion, which actually forms the ventral part of the ring. Bodian preparations show nerve fibers ramifying through this tissue. The anterior, dorsal group of small cells is closely associated with the connecting tracheal trunk, but the cells comprising the organ may be distinguished from those of the imaginal bud cells by their larger size and the more regular outline of their nuclei. In a frontal section through this region there will be, therefore, nuclei of three distinct sizes. The two large types are spherical, and are approximately 12 and 9 microns in diameter respectively. The smallest nuclei are oval and measure approximately 7 x 8 microns. This is true also of *Drosophila*, where the respective nuclear sizes are 12, 6 and 5 x 6 microns. In *Lucilia* this group of small cells is median in position and not very conspicuous even in the late larva, where there are approximately ten cells, but, as will be shown below, these cells become more conspicuous in the adult fly.

*II. The Prepupa.*—No gross morphological differences distinguish the gland of this stage from that of the late larva, but the large ring gland cells become vacuolated, as shown by Burt (1937) in *Calliphora*. Burt considers this as evidence for the production of a hormone at this stage, and there is experimental evidence that a puparium-forming hormone is secreted from this region of the insect (Fraenkel, 1935, on *Calliphora*; De Bach, 1938, on *Musca*; Hadorn, 1937, Bodenstein, 1938, on *Drosophila*). It would be of interest to correlate the time of appearance of these vacuoles with the "critical period," which varies considerably in the flies mentioned. The vacuoles vary in size from one cell to another, and may occupy so much of the cell that the cytoplasm and nucleus are restricted to the periphery (fig. 5). No changes occur in the nerve cell bodies or in the other cell types, except that mitoses are found in the imaginal bud cells surrounding the tracheae and occasionally in the anterior group of small cells.



*III. The Two-hour Pupa.*—Such a pupa has not yet become fully pigmented. Some of the larval musculature is still intact, but the body cavity contains mainly conspicuous fat body cells and phagocytosed material. At this stage the gland is noticeably shortened, and the anterior part has become more dorsal in position. It still retains its connection with the larval aorta dorsally. Any vacuoles which may have characterized the large gland cells of the prepupa have now disappeared, and the cells exhibit an abundant, uniform cytoplasm, which is still relatively acidophilic as in the larva. The nuclei have increased somewhat in size (up to 22 microns in diameter) and may be irregular in outline. On the basis of the histological appearance of these cells and from a comparison of them with those of other stages, it would appear that they are very actively secreting in the early pupa. In the 12-hour pupa there is little visible change in the structure of the ring gland, but after the 24-hour stage the large gland cells begin to undergo degenerative modification.

*IV. The Twenty-four-hour Pupa.*—During this time the larval tissues are being further broken down, and the aorta becomes separated from the ring gland, which henceforth has no direct connection with the larval aorta. Marked changes are also occurring in the tracheal system, for at this time new tracheal branches are arising from the imaginal bud cells which surround the tracheae supplying the ring gland of the larva. (Compare Poulson, 1935, on oxygen uptake by *Drosophila* pupae.) The gland has moved posteriorly away from the connecting trunk, so that the small imaginal bud cells no longer constitute part of it. Also in the 24-hour pupa the small dorsal cells have undergone mitosis to form a larger group of cells, with nuclei characterized by their uniform shape and their single, large nucleolus. Thus, between the 12-hour and the 2-day stage they undergo their most marked changes, and so differ markedly from those of the moth, *Ephestia* as described by Schrader (1938).

*V. The Two-day Pupa.*—By this time the gland has shortened to almost its final length, and moved posteriorly from the brain (figs. 2 and 2A). This shortening has resulted from a decrease in the size of the gland cells and their aggregation to form a more compact organ (fig. 6). At the same time the gland is rotated so that the anterior part becomes more dorsal in position. Mitoses may still be found in the dorsal group of small cells, though these have almost reached the number present in the adult. This group is now entirely surrounded by the large gland cells. Occasional lymphocytes, with large fuchsinophil droplets in their cytoplasm, are found among the large gland cells, and throughout the pupa. The nerve cell bodies of the hypocerebral

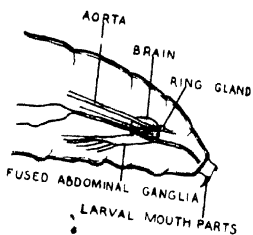
#### EXPLANATION OF PLATE I

Semidiagrammatic longitudinal sections of *Lucilia sericata*, showing relationships of brain, dorsal vessel, gut, and ring gland. Various magnifications.

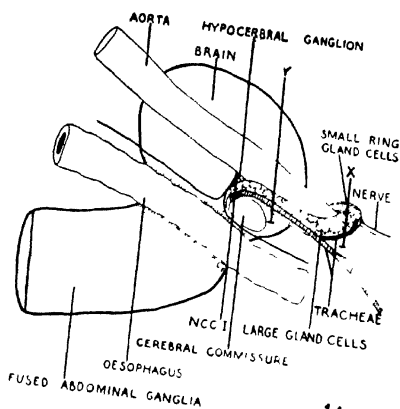
Fig. 1. The full-grown larva. 1A. Enlarged portion of 1, showing innervation and tracheation. "X" indicates plane of Fig. 4, and "Y" the plane of Fig. 5. 2. Two-day pupa. 2A. Part of 2, enlarged. 3. Young male. 3A. Part of 3, enlarged.

Ring Gland of Diptera  
M. F. Day

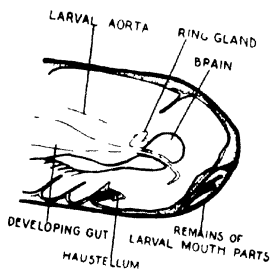
PLATE I



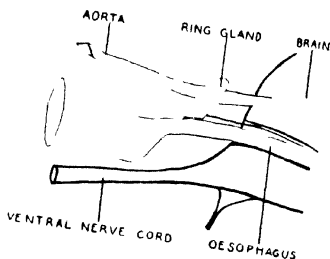
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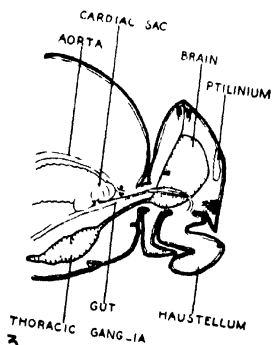
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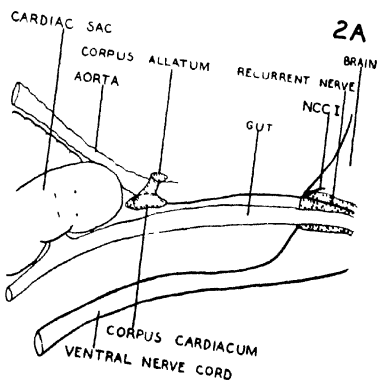
2



2A



3



3A

ganglion are somewhat separated and lie between the developing gut and the cell of the ring. The nuclei of the large gland cells are very conspicuous, and with the decrease in the amount of cytoplasm, the cells become more basophilic.

**VI. The Four-day Pupa.**—By this time the flight muscles of the adult fly are well formed. The gland has moved still farther posteriorly, but since the gut has not yet produced the cardiac sac, it cannot be said to occupy the final position which it will attain in the adult. No great changes have occurred in the cells of the gland.

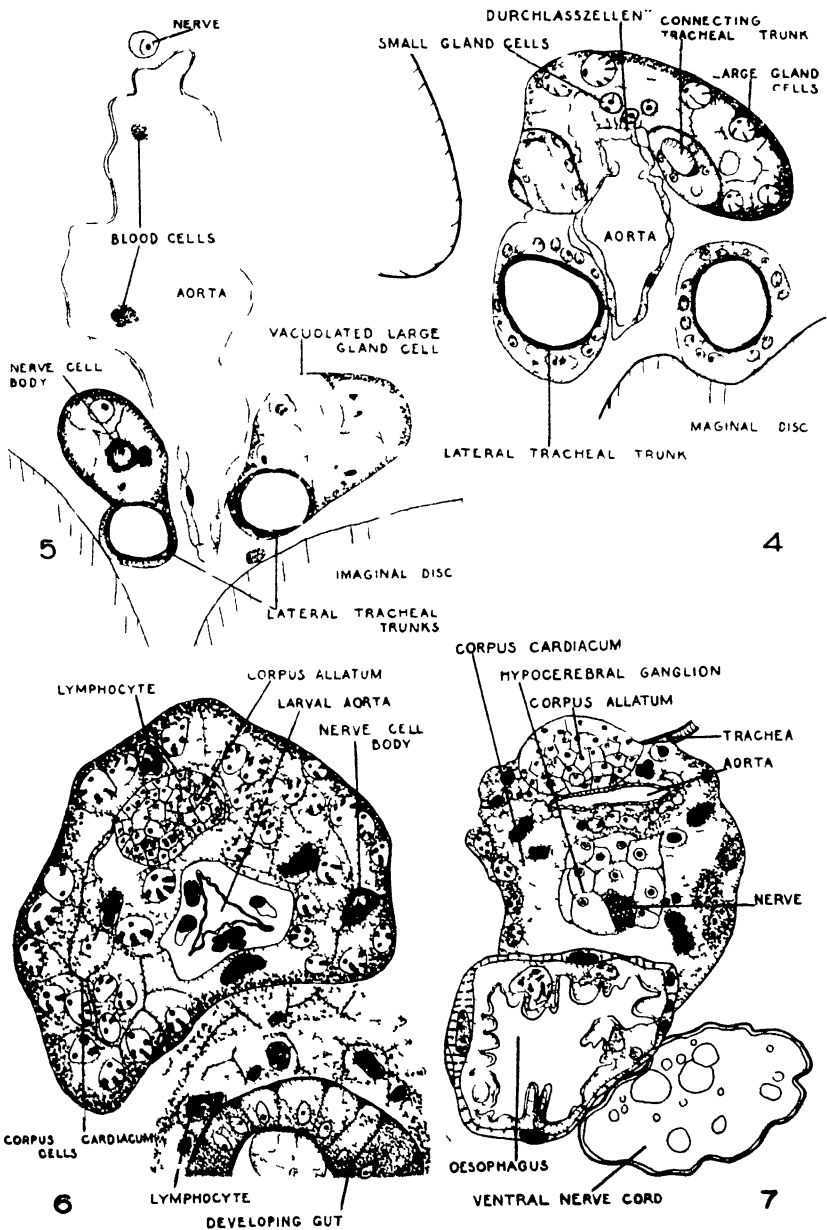
**VII. The Six-day Pupa.**—The gland has decreased considerably in size, due to the disappearance of much of the cytoplasm of the large gland cells. These have migrated, and may almost entirely surround the hypocerebral ganglion. The gland is now situated just anterior to the cardiac sac, and so occupies the position it does in the adult fly. The only changes seen from this condition to that in the 8-day pupa are further decreases in the amount of the cytoplasm of the large gland cells and the consequent decrease in the size of the ring.

**VIII. The Adult.**—At the temperature of the culture room the adult flies emerged between 9 and 11 days after puparium formation. The condition of the incretory organs in a freshly emerged male is shown in figs. 3 and 3A. The two nerves (NCC I) have increased considerably in length, and now run posteriorly from the brain, instead of anteriorly as they did in the larva. Together with the recurrent nerve (apparently arising from the frontal ganglion, though this is much reduced in the adult *Lucilia*) they unite to form a single compound nerve in the region of the cervix. The large gland cells are profusely innervated by fibers from the recurrent and from the two NCC I nerves. Nerve fibers ramify in all directions between these cells, and also between the more closely packed small gland cells. Nerve endings within these cells have not, however, been conclusively demonstrated, and a similar situation exists in the corpus allatum of the honeybee and the moth, *Ephestia*. The tracheal supply of both cell groups is from one of the thoracic air sacs, which sends a trachea to supply the cardiac sac, and from this trachea a small branch runs anteriorly to the incretory organs.

#### EXPLANATION OF PLATE II

Transverse sections of ring glands of *Lucilia sericata*, showing histological details. All approximately  $\times 350$ , except Fig. 6, which is  $\times 250$ . Drawn with the aid of a camera lucida.

Fig. 4. Anterior of ring gland of full-grown larva. Note "Durchlasszellen," small histoblast cells surrounding tracheae, medium-sized corpus allatum cells, and large corpus cardiacum cells. 5. Posterior part of the ring gland of prepupa, showing that the gland is separated from the aorta in this region. Note also the vacuole in one of the large corpus cardiacum cells, and the nerve cell body. 6. Ring gland of 2-day pupa. Note enlarged corpus cardiacum cells, the degenerating larval aorta, the lymphocytes, and the mitoses in the corpus allatum cells. The marked decrease in size of the gland between this stage and that shown in Fig. 7 is rendered less conspicuous by the differences in magnification. 7. Corpus allatum and corpora cardiaca of young adult male. Note decrease in cytoplasm of corpora cardiaca cells, the mature, compact corpus allatum cells, and the nerve cell bodies of the hypocerebral ganglion.



The small gland cells form a compact group dorsal to the poorly-developed aorta, while the remains of the large gland cells form masses on each side of the latter. Ventral to the aorta, and slightly posterior to the dorsal group of small cells is the hypocerebral ganglion in which the nerve cell bodies represent the most important element. From their position, their relationships, and their innervation, the dorsal small cells will be seen to constitute the median corpus allatum of the type briefly described by Thomsen (1940). It is likewise definite by applying the above criteria to the condition in other insects that the large gland cells represent the corpora cardiaca, the reverse of the condition suggested by Scharer and Hadorn. As further evidence of this conclusion it might be mentioned that the cells of the corpus allatum of *Tipula abdominalis* Say are smaller than those of the corpus cardiacum; also that in *Tabanus atratus* Fab. the corpus cardiacum cells are not contiguous with those of the corpus allatum, so there is less doubt of the homologies. It will be seen that the statement of Hanström (1939, p. 54) is most nearly in accord with the present conclusions, although he did not consider the small corpus allatum.

From the histological picture it seems most probable that the corpus allatum cells are not very active in the larva, while, as mentioned previously, the corpus cardiacum cells appear to be extremely active. (The recent results of Vogt, 1940b, might be considered evidence against this conclusion, for she has shown that the *Drosophila melanogaster* ring gland produces gonadotropic hormone at least a day before puparium formation). In the adult, however, the situation is reversed, and the corpus allatum is the most active organ, and is probably the source of the gonadotropic hormone reported by Vogt (1941b). In adult *Lucilia* several days of age large masses of fuchsinophil material, stable to the ingredients of alcoholic Bouin's fixative, appear first within the corpus cardiacum cells and later in the intercellular spaces. This material is considered to be products of secretion of these cells, but it is not known what might be its physiological significance. In older flies (more than 12 days of age) most of the material has again disappeared. During this time, however, no changes can be observed in the cells of the corpus allatum. They remain uniform in size, compact, and are difficult to differentiate. The nuclei have decreased in size from those of the early pupa (6 x 8 to 3 x 4 microns), consequent upon their increase in number.

There is one possible objection to the above conclusions. The only portion of the "ring" of the adult possessing the characteristic bluish appearance which typifies the living corpora cardiaca of a number of insects (and also the sinus gland of Crustacea), is the ventral part which has been considered to represent principally the cells of the hypocerebral ganglion. It might be added, however, that none of the cells of the larval ring gland exhibit this bluish appearance. If this characteristic be considered significant, it would be necessary to conclude that the large gland cells of the larva, and the remains of these cells in the adult, represent a development which is confined to the higher Diptera.

## DISCUSSION

There have been so few observations on the function of the corpus cardiacum in other insects, and the conditions in the higher Diptera are so aberrant, that comparisons are difficult to evaluate. There is much evidence, however, that insect hormones are frequently non-specific. Removal of the corpus cardiacum of *Melanoplus* seems to cause some delay in moulting (Pfeiffer, 1939). Again, if the nerve cell bodies of the NCC I are in the pars intercerebralis, it is possible that the removal of this region in *Rhodnius*, as was done by Wigglesworth (1940), results in altered secretion of the corpus cardiacum, though his conclusions are substantiated by the results of transplanting the pars intercerebralis. Although puparium formation follows shortly after the vacuolization of the corpus cardiacum cells, as reported by Burt (1937) and confirmed in this study, the larva undergoes a further moult within the puparium, and it may be that these changes are more directly concerned with the moulting process than with that of puparium formation. Nevertheless, puparium formation is definitely under the control of a hormone (cf. Fraenkel, 1935; Plagge and Becker, 1938; and others). The experiments of Burt (1938) and Hadorn (1937) demonstrate that it is probably the ring gland which is the source of this secretion. It is believed, however, that the processes going on at this time are far too complex for any simple explanation to be considered adequate. Nothing has been published on the effects of the corpus cardiacum in adult insects, except that it hypertrophies along with the corpus allatum in the reproductive castes of termites (Pflugfelder, 1937). Numerous experiments, however, have indicated that the corpus allatum may exert some effects in the adult on the maturing of the eggs and on secretion in the oviducts. And more specifically, the results of Thomsen (1940), indicating that there is a reciprocal action between the ovaries and the corpus allatum of flies, suggest that the latter gland is particularly concerned with the sexual processes in these insects. While the results of Vogt (1940a) are significant in this connection, it is not possible to determine from her experiments which portion of the ring gland is active in inducing development of ovaries in the heteroplastic transplants which she describes. In a more recent work Vogt (1941a) has described changes in the ring gland of *Drosophila melanogaster* occurring during pupal development which are not dissimilar to those described above. However, Vogt has referred to the corpus allatum cells as "median ganglion."

## SUMMARY

The ring gland of the full-grown larva of *Lucilia sericata* Meig. is described. From the fate of the cell types as they are transformed into the adult corpus allatum and corpora cardiaca, it is concluded that the large ring gland cells are the corpus cardiacum cells. A median group of small cells dorsal to the aorta increases in size, and the cells increase in number by mitosis during pupal development to form the median corpus allatum of the adult. Some histological changes in the cells during development are described.

The bearing of these conclusions on our present knowledge of insect hormones is briefly discussed.

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# ANOPHELES (NYSSORHYNCHUS) SAWYERI, A NEW ANOPHELINE MOSQUITO FROM CEARA, BRAZIL<sup>1</sup>

O. R. CAUSEY, L. M. DEANE, M. P. DEANE, and M. M. SAMPAIO,  
Rockefeller Foundation,  
New York, N. Y.

One of the most widely distributed anophelines of the *Nyssorhynchus* group is *Anopheles argyritarsis* Robineau-Desvoidy. Although the species has been recognized for more than one hundred years, no very closely related forms have been described from its wide range throughout the Neotropical region. There is evidence accumulating, however, to indicate that with future intensified studies on biological and morphological characters the mosquitoes now designated as *Anopheles argyritarsis* will be classified in a number of valid species.

Such a new species has recently been discovered in Brazil among specimens collected in an anopheline survey. Examination of eggs, larvae, pupae, adult coloration, and male genitalia revealed characters which clearly separate it from *A. argyritarsis*. We herewith describe the species and name it *Anopheles (Nyssorhynchus) sawyeri*, in honor of Dr. Wilbur A. Sawyer, director of the International Health Division of The Rockefeller Foundation.

The type specimen and paratypes were bred out in the laboratory from eggs collected from wild females captured on horse bait on the high plateau of Serra da Ibiapaba near São Benedito in Ceará. So far the new species has been encountered only in this area, although extensive regions of Northeast Brazil have been surveyed. Since the type locality is apparently free of malaria, and the mosquito was never abundant and never found inside houses, *Anopheles sawyeri* is not suspected of being a vector. The holotype female and paratype males and females, larvae, and larval and pupal pelts have been deposited in the National Museum of the United States in Washington, D. C. Paratypes, larvae, and larval and pupal pelts are also deposited in the Oswaldo Cruz Institute in Rio de Janeiro.

## DESCRIPTION OF ADULT

**FEMALE: Vertex.**—Very long, narrow white setae; white scales of median portion much shorter and broader, semierect; row of white scales around eyes still smaller, recumbent.

**Occiput.**—Abundant, compact, large, broad, erect, truncate scales, some notched at tip; scales of median and anterior portions white or yellowish; scales at lateral portions black.

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<sup>1</sup>The studies herewith reported were part of the program of the Serviço de Malaria do Nordeste maintained jointly by the Ministry of Education and Health of Brazil and the International Health Division of The Rockefeller Foundation.



*Proboscis*.—Dark brown, almost black.

*Palpus*.—Segment I with black erect scales; segment II with black semierect scales except for narrow white apical ring; segment III with black recumbent scales, and apical ring of white scales. Segment IV all black; segment V all white (Plate I, fig. 2).

*Antenna*.—Torus dark, with few small white scales; first segment of flagellum with more numerous white scales, some much larger than others; remainder of flagellum scaleless, but covered with very small delicate pale hairs; long dark setae at articulations of joints.

*Anterior pronotum*.—Compact group of large, erect, truncate, black scales at anterior portion; remaining portion sparsely clothed with long dark setae.

*Posterior pronotum*.—Bare.

*Propleura*.—Few long dark setae.

*Mesopleura*.—Bare.

*Sternopleura*.—Group of larger white scales below middle of sclerite, close to posterior margin, and another at upper portion; few dark setae near scales.

*Mesoepimeron*.—Row of long pale setae at upper portion.

*Mesonotum*.—Triangular dark spot at prescutellar space, and smaller rounded spot at each side, posterior to lateral fossae; vestiture composed of white recumbent scales.

*Scutellum*.—Integument dark at median portion and paler at sides; clothed with recumbent white scales like those of mesonotum and with dark bristles; row of long dark bristles along posterior margin.

*Abdomen*.—Except on sternite I, clothed with numerous long dark bristles, largest at posterior portion of tergite I. Inconspicuous posterior lateral tufts of dark scales on segments III to VII. Tergite I scaleless; tergite II with triangular area formed by yellow and white recumbent scales; tergites III to VII with gradually larger and less triangular pale areas; tergite VIII with broad basal band of yellowish scales; narrow row of lighter scales at posterior margin. Sternite I bare; sternite II without dark scales and with two longitudinal submedian areas shorter than sternite; sternite III with very rare dark recumbent scales near anterior margin close to median line, and white scales chiefly distributed near posterior corners; sternites IV and V with more numerous dark scales at posterior margin, and white scales forming three groups, two near posterior corners and third at median line slightly before middle; sparse scales on remaining portions; sternite VI with dark scales at posterior margin, and white scales forming elongate median patch, two patches at posterior corners, and two submedian patches close to anterior margin; sternite VII with abundant black scales at posterior margin; white scales in longitudinal patch extending to anterior margin, and in submedian patches at anterior margin; sternite VIII with black scales more abundant than on VII, and with scales forming two longitudinal bands from anterior to posterior margins, close to lateral margins. Cerci clothed dorsally with dark brown or black scales at outer portion

and white (few yellowish) scales at inner portion; ventral surface largely covered with dark scales; white scales only at apex and on small distal portion at inner margin.

*Front tarsi*.—Segment I dark at outer portion except for narrow white apical band, inner portion with line of white scales; segment II black with apical portion about two-sevenths white; segment III black with very small white apical ring; segments IV and V entirely dark.

*Mid tarsi*.—Dark except for few scattered pale scales at apex of first and second segments, in some specimens all black.

*Hind tarsi*.—Segment I dark on outer portion, light on inner portion, except on distal third where dark scales predominate, apex black; segment II with basal black portion measuring 19 per cent of entire length in type specimen, remainder white, black portion 8 to 24 per cent in other specimens; segments III, IV, and V white (Plate I, figs. 3a, b, c).

*Wing*.—Pale portions formed by white scales, dark areas formed by coal black scales. Costa: B1 large, B2 much smaller than B1 but larger than preceding black spot, which does not reach humeral cross vein; B3 narrow, much smaller than preceding black portion; M1 usually absent, M2 approximately size of B2; Sc less than one quarter length of preceding black portion; Ap larger than Sc.

*Subcosta*.—Base pale, M1 present, M2 sometimes present, the remainder black.

*First vein*.—Base white, M1 as on subcosta, M2 slightly larger, Sc much larger than on costa, Ap slightly larger than on costa, apex with small black spot.

*Second vein*.—Stem with small basal black ring, followed by white spot corresponding to M2 of first vein; large black area extending to base of third vein followed by two alternate white and black areas, the last black area largest and extending to fork of vein; upper branch with small basal white spot followed by large black spot, with another white spot corresponding to Ap on first vein but smaller, another black spot of about size of preceding white spot; lower branch with small white basal area, followed by two black and two white alternate spots, tip white.

*Third vein*.—White, with rather broad subbasal and narrower sub-apical black spots.

*Fourth vein*.—Stem white with large black area beginning basal to level of insertion of second vein, and smaller black area at apex; upper branch with small basal white spot followed by two black and two white alternate spots; lower branch, base and apex white, with intermediate black portion.

*Fifth vein*.—Stem white, with subapical black spot; upper branch predominantly white, with two small black spots on basal half and third spot near apex; lower branch white, with subapical black spot.

*Sixth vein*.—White, with small black spot near base and a larger black area near apex.

Fringe formed by brownish-gray scales and white scales at portions corresponding to tips of longitudinal veins (Plate I, fig. 1).

**MALE GENITALIA:** In general similar to *A. argyritarsis*, differing principally in structure of mesosome and fused dorsal lobes. Membranous tip of mesosome longer and more pointed than in *argyritarsis*. Leaflets narrow, straight, serrated, closely approximated to lateral surface of mesosome, rarely incurved as in *argyritarsis* (Plate II, figs. 6a, 6b, 7). Apex of fused dorsal lobes very broad; outer corners sharply rounded with deep excavation of apical border (Plate II, fig. 8). Easily distinguished from *argyritarsis* which has a narrower apex with low rounded corners and shallow excavation (Plate II, fig. 9).

**DIFFERENTIATION FROM *A. ARGYRITARSIS*:** The 100 female specimens of *Anopheles sawyeri* studied are very much like the 47 specimens of *Anopheles argyritarsis* collected in Ceará and Rio de Janeiro. However, there seems to be a larger amount of white on the costal portion of the wings of *argyritarsis*, especially in specimens from Rio de Janeiro. The B2, for instance, in the majority of *argyritarsis* is much larger than the preceding black spot (two or three times larger or more, since B1 and B2 are sometimes fused); in the majority of specimens of *A. sawyeri* B2 is less than twice the size of the preceding black spot. Spot M1 was absent in 91, vestigial in 5, and present in 4 out of 100 specimens of *A. sawyeri*, while present or vestigial in 39 of 47 specimens of *A. argyritarsis* examined.

## DESCRIPTION OF IMMATURE STAGES

**EGG:**—Floats absent; general size and shape of egg similar to *A. argyritarsis*, but with slightly greater concavity of dorsal surface (Plate III, fig. 11). Anterior end somewhat broader than posterior end. Exochorion dark, showing hexagonal pattern on dorsal surface enclosed by frill (Plate III, fig. 10). Wide frill continuous around entire dorsolateral area, much broader at ends (Plate I, figs. 4 and 5).

**LARVA:**—Inner clypeal hairs very close together, long and slender, with few and minute lateral branchlets. Outer clypeal hairs much shorter than inner ones, with few delicate lateral branches usually more conspicuous than those on inner hairs.

Posterior clypeal hairs long and slender, usually single, sometimes bifid.

Terminal hair of antenna long and slender, usually single, sometimes trifid.

Antennal hair situated on distal portion of basal quarter of antenna; small, with about 5 branches.

Inner submedian prothoracic hair with 9 to 15 filamentous branches.

Basal spines of pleural groups of hairs stout and very short.

Palmate hair of metathorax with about 10 filamentous leaflets.

Palmate hair of first abdominal segment with about 12 filamentous leaflets lightly chitinized; palmate hairs of abdominal segments II to VII with enlarged flattened, well chitinized leaflets, having very sharp and long almost filamentous tips (Plate III, fig. 12). Tips on corresponding leaflets of *A. argyritarsis* shorter and thicker.

**PUPA:**—Trumpet relatively long and narrow with little distal expansion (Plate IV, fig. 13).

Hair A minute and transparent on segment II; usually slightly larger and darker on segment III; larger, blunt, and well chitinized on segment IV; very long, well chitinized, usually slightly curved, and with tapering tips on segments V to VIII (Plate IV, fig. 14). Hair A on segment IV about one-eighth length of segment, slightly more than one-half length of segment on V and VIII, longer on VI; usually shorter and sometimes bifid or with few irregular external spinous branches on VIII (Plate IV, fig. 16).

Pupa of *sawyeri* differs from *A. argyritarsis* in proportional length of hair A on segments IV and V. Hair A on segment IV of *A. sawyeri* is usually less than one-fifth length of same hair on segment V, while in *A. argyritarsis* hair A on segment IV is more than one-fifth length of hair A on segment V (Plate IV, fig. 15).

Paddle of *sawyeri* is pear-shaped, proportion of length to width about 1.5. Outer margin with a row of very small teeth beginning near middle and grading into a fringe of delicate but conspicuous hairs extending to distal tip of margin; inner margin entirely bare. Terminal hair rather long, single, and strongly hooked; accessory hair very slender (Plate IV, fig. 17).

### SUMMARY

Eggs, larvae, pupae, adult female, and male genitalia are described and figured from *Anopheles (Nyssorhynchus) sawyeri*, a new species of anopheline from Northeast Brazil. *Anopheles sawyeri* resembles *Anopheles argyritarsis* but can be differentiated from it in all stages of the life cycle, and by the male genitalia. The new species was found only on one plateau, in small numbers and feeding only on animal bait. It is therefore not suspected of being a malaria vector.

## EXPLANATION OF PLATES

## PLATE I

(Camera lucida drawings)

- Fig. 1. Wing, female, *A. sawyeri*. Fig. 2. Palpus, female, *A. sawyeri*. Fig. 3. Tarsi. a. front, b. middle, c. hind, female, *A. sawyeri*. Fig. 4. Egg, lateral view, *A. sawyeri*. Fig. 5. Egg, dorsal view, *A. sawyeri*.

## PLATE II

(Microphotographs)

- Fig. 6. a. male genitalia, mesosome, *A. sawyeri*; b. same with one leaflet displaced. Fig. 7. Male genitalia, mesosome, *A. argyritarsis*. Fig. 8. Male genitalia, dorsal lobes, *A. sawyeri*. Fig. 9. Male genitalia, dorsal lobes, *A. argyritarsis*.

## PLATE III

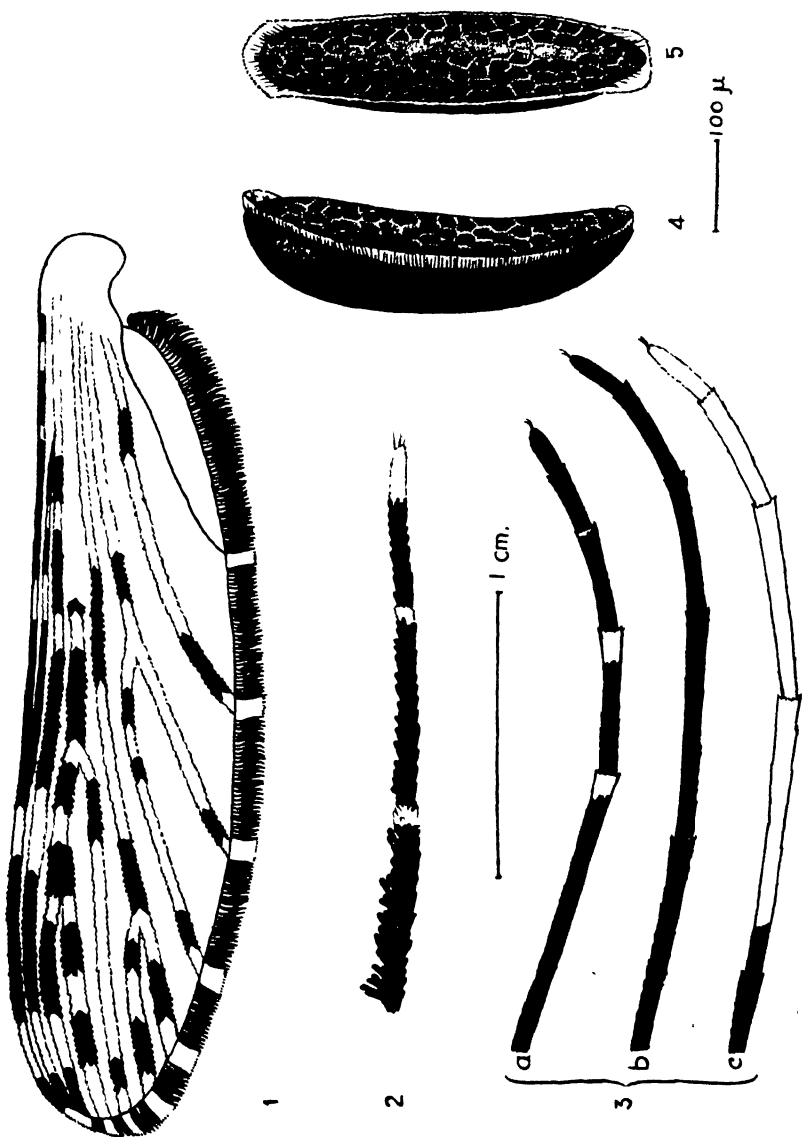
(Microphotographs)

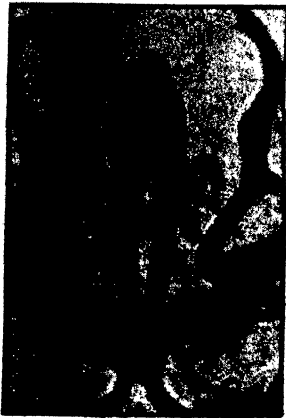
- Fig. 10. Eggs, dorsal view, *A. sawyeri*. Fig. 11. Egg, lateral view, *A. sawyeri*. Fig. 12. Larva, palmate hair, *A. sawyeri*.

## PLATE IV

(Camera lucida drawings)

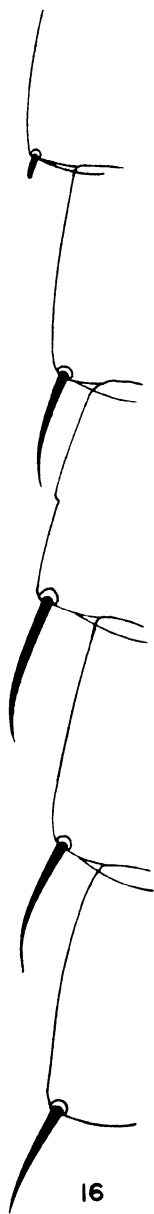
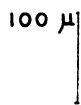
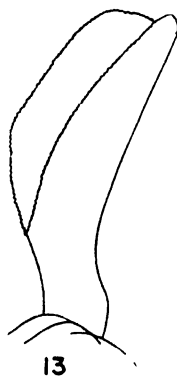
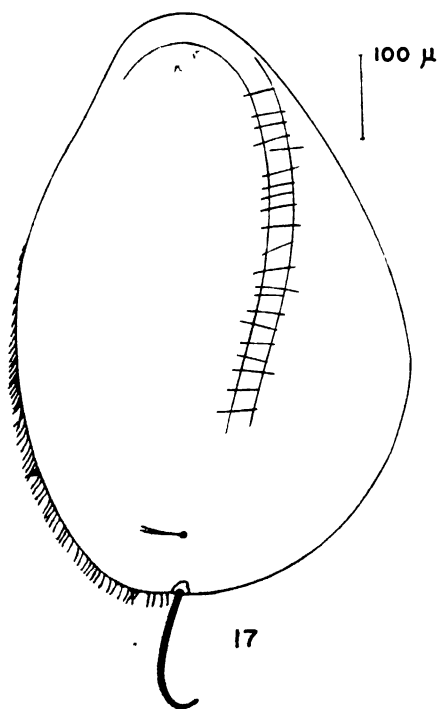
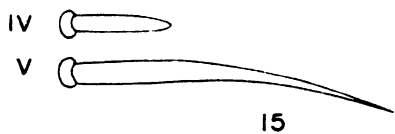
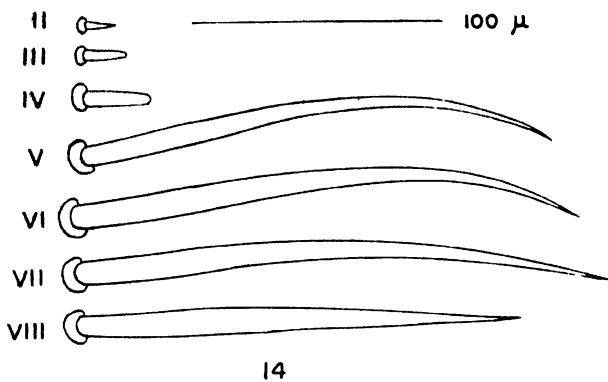
- Fig. 13. Pupa, trumpet, *A. sawyeri*. Fig. 14. Pupa, hair A of abdominal segments II to VIII, *A. sawyeri*. Fig. 15. Pupa, hair A of abdominal segments IV and V, *A. argyritarsis*. Fig. 16. Pupa, relative lengths of hair A and abdominal segments IV to VIII, *A. sawyeri*. Fig. 17. Pupa, paddle, *A. sawyeri*.











# MOSQUITOES AS VECTORS OF DERMATOBIA IN EASTERN COLOMBIA<sup>1</sup>

MARSTON BATES  
Rockefeller Foundation,  
New York, N. Y.

The "human warble fly" (*Dermatobia hominis*) seems to be particularly common in the forest zone at the base of the Eastern Andes in Colombia, and in the course of yellow fever work in this zone observations have been accumulated on this warble fly that may be of general interest. In making routine captures of mosquitoes in several areas near Villavicencio for the purpose of checking on seasonal and habitat changes, the incidence of mosquitoes with *Dermatobia* eggs was noted on the record sheets. From these it has been possible to compute the relative frequency of infestation of different mosquito species. It has also often been possible to observe the behavior of the adult *Dermatobia* while ovipositing, and as accounts of this behavior in the literature are in part conflicting, a summary of the observations made is included in the present paper. This insect's oviposition habits are of great biological interest, entailing a curious vector relationship with mosquitoes and other flies; the behavior of the adult *Dermatobia* is surely as complicated and as inexplicable as that of any known insect, comparable to the highly specialized behavior patterns of some of the Hymenoptera.

The literature on *Dermatobia* is extensive, but refers for the most part to incidence on mammalian hosts and to the identification of insects on which the eggs have been found. The most detailed accounts of the bionomics of the fly are by Sambon (1915, 1922) and Neiva and Gomes (1917). Peña and Kumm (1939) have published some excellent photographs of mosquitoes bearing *Dermatobia* eggs. The insect is a major pest of cattle in many parts of Colombia, and detailed studies would be fully warranted from the agricultural point of view.

## OVIPOSITION BEHAVIOR

The adult *Dermatobia* female, when ready to lay eggs, appears to be attracted to warm-blooded animals; these females have often been observed both on field workers and on their horses. The following, for instance, is an abstract from field notes: "Observed an adult *Dermatobia* on the flank of my horse in the Bosque Ocoa; she oviposited on four muscoid flies in a period of 45 minutes. She stationed herself on the horse's flank, making short flights from time to time, changing occasionally from one side of the horse to the other. The small flies were captured as they approached the *Dermatobia*; when they were perhaps a centimeter away she would pounce on them, catching them in mid-air; the

<sup>1</sup>The studies and observations on which this paper is based were conducted with the support and under the auspices of the Section of Special Studies maintained by the Ministry of Labor, Hygiene, and Social Welfare of the Republic of Colombia and the International Health Division of The Rockefeller Foundation.

flies were held closely under the thorax of the *Dermatobia* while she hovered; the oviposition process required approximately one minute."

The *Dermatobia* are quite fearless and on one occasion I spent some time playing with a female that lit on my shoulder. I induced her to crawl onto the tip of a finger and then tried bringing her close to mosquitoes that were feeding. She seemed quite indifferent to a stationary mosquito and even when the mosquitoes flew away after feeding, the *Dermatobia* usually did not give chase. I finally placed her on the bare foot of one of the men, where several mosquitoes were feeding. The *Dermatobia* seemed to react to the mosquitoes only when they moved, and was thus most likely to attempt to catch them when they first lit. In this position the *Dermatobia* was so close to the ground that when she caught a mosquito she was likely to strike the ground while attempting to hover; she completed the oviposition process twice while lying in the leaves after such contretemps, and I was able to observe the action with a hand lens. The mosquito was grasped firmly in all six legs of the *Dermatobia* and pressed, head forward and back up, against her thorax; the eggs were then planted in rapid succession on the abdomen of the vector, this site being easily reached by the curving abdomen of the *Dermatobia*. The process is clearly normally carried out while hovering, and it was only when the vector was already properly oriented and actual oviposition started that the pattern was not broken by striking the ground.

The *Dermatobia* adults often have difficulty in handling their captures and they frequently fail to complete the oviposition process. The first action after capturing a potential vector is to turn it about to get it properly oriented for oviposition, and it is often lost in this period; my impression is that *Dermatobia* cannot handle a potential vector that is too large, too small, or too active. Large flies are sometimes captured but escape, and I have seen *Haemagogus* escape in the pre-oviposition struggle, so it may be that this species is too small to be a satisfactory vector.

I have found *Dermatobia* adults only in forest and during midday hours. Twice, however, flies that have stationed themselves on my shoulders while I was working in the forest have remained in position during a two kilometer walk from the forest station to the highway, the latter half of the walk being across sunny pasture. Once also, after leaving a forest, a *Dermatobia* stayed on my horse over several kilometers of open road.

### INCIDENCE OF EGGS ON MOSQUITOES

Small calypterate flies are probably as frequently vectors of *Dermatobia* as are mosquitoes; but to establish rates for these flies it would be necessary to catch all of the flies that hover about one while in the forest. As the primary aim has been to study mosquitoes, no attempt has been made to collect zoophilous flies in general. The mosquito fauna of the Villavicencio area has been described in papers by Komp (1936) and Antunes (1937); the nomenclature used here corresponds to theirs, except that *Wyeomyia* is used in the wide sense of Edwards (1932).

The incidence of *Dermatobia* eggs on mosquitoes varies according to locality and mosquito species. The highest rate is in a small forest near the laboratory called the "Bosque Ocoa"; this forest is partly second

growth and partly a somewhat cutover remnant of what might be called the "plains forest," a forest that probably originally covered the level ground from the base of the eastern Andes for a distance of twenty or thirty kilometers into the llanos but which, in the vicinity of towns and roads, has been almost entirely cleared. This type of forest is characterized by an abundance of ground-pool breeding mosquitoes (especially *Psorophora ferox* and *Aedes serratus*) which are rare in the better drained foothill forest. Infestation rates in the Bosque Ocoa were:

Species	Number Examined	Number Infested	Per Cent Infested
<i>Psorophora ferox</i> .....	822	69	8.4
<i>Aedes serratus</i> .....	1,172	26	2.2
<i>Haemagogus capricorni</i> .....	128	0	0
Miscellaneous sabethines.....	866	2	0.2

The sabethines were very largely *Wyeomyia*; both specimens with eggs belonged to that genus. *Psorophora ferox* were caught with eggs during every month of the year, but the numbers for each month were too small to show possible seasonal variations. A stable trap, baited with a donkey, was run on three nights a week in a clearing in this forest. *Dermatobia* infestations on mosquitoes caught in the trap during a year of collections were as follows:

Species	Number Examined	Number Infested	Per Cent Infested
<i>Psorophora ferox</i> ....	122	2	1.6
<i>Aedes serratus</i> .....	1,669	4	0.2
Miscellaneous sabethines.....	516	1	0.2
<i>Anopheles rangeli</i> .....	22,116	0	0
<i>Mansonia</i> spp.....	3,799	3	0.1
<i>Psorophora cingulata</i> .....	7,997	5	0.1

The difference in infestation between the day captures and the trap captures in *Psorophora ferox* and *Aedes serratus* is significant. These species enter the trap in numbers only during periods of great abundance (at the time of the first rains, for instance) so that the majority of specimens so caught may be recently emerged and thus less likely to be infested. The *Mansonia* are almost exclusively a species that seems to be *justamansonia*, which is never taken in the day captures; *Psorophora cingulata* is very rare in the day captures also, and the crepuscular habit may account for the low infestation rate in both of these species. The sabethines were again mostly *Wyeomyia*, and the one specimen with eggs belonged to that genus.

Regular day captures were made in an area of foothill forest which we call "La Forzosa" (all forests mentioned here are subdivisions of the general class of "lower tropical rain forest"). There, because of the complete drainage, ground-pool breeders are very rare and the fauna is composed almost exclusively of mosquitoes that breed in "natural containers." The infestation rates were:

Species	Number Examined	Number Infested	Per Cent Infested
<i>Psorophora ferox</i> .....	137	0	0
<i>Aedes serratus</i> .....	43	1	2.3
<i>Haemagogus capricorni</i> .....	8,628	3	0.03
<i>Wyeomyia</i> spp.....	1,992	10	0.5
<i>Anopheles boliviensis</i> .....	318	1	0.3

The only other mosquito caught in the area with *Dermatobia* eggs was a specimen of the rather rare *Trichoprosopon lampropus*.

It is apparent that *Dermatobia* is relatively scarce in the Forzosa area. Presumably cattle are the chief mammalian host and the two forest areas are about equally distant from pastures (about a kilometer in each case). The Ocoa forest is on the highroad along which thousands of cattle are driven and the *Dermatobia* might come from these passing animals. Yet, in a series of captures made in a small patch of second growth along this same highroad, surrounded with cattle pastures, a rate of only 0.7% on *Psorophora ferox* (3 in 448) was found. A similar great difference was observed between two forests near the town of Acacias, in the course of a short study there: in one forest 11 of 263 *Psorophora ferox* carried eggs of *Dermatobia*; in the other, none of 346 *Psorophora ferox*. In this case both were "plains forests," but the one with the high *Dermatobia* rate was much cut over, and had somewhat larger numbers of cattle in the immediate vicinity.

## DISCUSSION AND SUMMARY

The adult female of *Dermatobia hominis*, when ready to lay eggs, is zoophilous in that she is attracted to warm-blooded animals; taking up a position on a man or a horse, she seizes other zoophilous flies and lays her eggs on them. From observations of the oviposition behavior and from the relative incidence of eggs on different species of mosquitoes, it would seem that the characteristics of a vector of *Dermatobia* eggs are: (a) zoophilous habit; (b) diurnal flying period; (c) moderate size (for instance most Tabanids would be too large to handle, *Hippelates* too small); (d) moderately active habits (very sluggish insects would not stimulate the pouncing behavior in *Dermatobia*, and very active ones would escape). Both *Dermatobia* and its vectors seem to be forest insects, though *Dermatobia* will occasionally leave the forest accompanying a host. The *Dermatobia* abundance may differ strikingly from forest to forest with no obvious relation to the abundance of cattle (assumed to be the chief host) in the vicinity.

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# FURTHER STUDIES ON OOTHECAE OF INTRODUCED ASIATIC MANTIDS

(Orthoptera: Mantidae)<sup>1</sup>

HENRY FOX,

Cape May Court House, New Jersey

The writer (1939a) published the results of a study of the oothecae of two species of Asiatic mantids established in this country. That study comprised observations on three lots of *Tenodera sinensis* Saussure and one of *T. angustipennis* Saussure. Of the former, two lots came from the Bronx section of New York City, one collected late in 1937, the other early in 1938. The third lot and the entire series of *T. angustipennis* were gathered late in 1937 at Ocean View, New Jersey. Since some of the conclusions based upon that material were provisional, their validity has been tested by an examination of additional material from the same localities.

## MATERIAL

The oothecae consisted of two lots of *T. sinensis* and one of *T. angustipennis*. Fifty-three oothecae of the former species and 88 of the latter were collected late in December, 1938, at Ocean View. Sixty-seven oothecae of *T. sinensis* were collected in mid-March, 1938, in the Bronx section of New York City.

## PROCEDURE

Most of the oothecae were promptly placed separately in glass jars, where they remained at room temperature until nymphal emergence had ended. Since jars were not available for the entire series obtained at Ocean View, part of the material from that locality was temporarily stored in an electric refrigerator. Development was thereby inhibited. Such procedure eliminated the complication which, in the previously reported experiments, arose as a result of exposing part of the eggs to cold after they had reached an advanced stage of development.

In the earlier work all oothecae were left dry during the entire period of observation. To reduce evaporation, the jars containing the oothecae were kept closed by fastening the glass lids in place by the metal clips, but omitting the rubber rings, thereby leaving the lids loose enough to allow a slow interchange of air between the interior of the jars and their surroundings. However, since under these conditions the loss of moisture from the oothecae might affect nymphal emergence, a modified procedure was adopted in part of the later series of experiments. All the oothecae from Ocean View which were kept uninterruptedly at developmental temperatures were sorted into two lots of nearly equal numbers. One lot was left dry to serve as a check,

<sup>1</sup>Contribution from the Department of Biology, University College, New York University.

while the other was moistened once each week by dipping the oothecae in tap water for about a minute and promptly replacing them in the jars. Traces of the moisture thereby introduced were often detectable in the jars for two to three days. Under natural conditions the oothecae are ordinarily dry on the surface and are only wetted during periods of damp or rainy weather. It was, therefore, inferred that alternate wetting and drying would more nearly approximate natural conditions than constant exposure to a high humidity, which might promote the growth of Fungi on the oothecae.

In every case, along with the total number of nymphs emerging from an ootheca, separate records were kept of those which appeared to be viable and of others which were moribund or otherwise defective. After emergence had ended, the oothecae, as in the earlier experiments, were dissected under a binocular and counts made of the number of eggs which had not developed and of nymphs which had either died within the egg or had perished while still inside the ootheca.

TABLE I  
Number of Eggs in Oothecae of *Tenodera*, 1938

SOURCE	NUMBER OF OOTHECAE	NUMBER OF EGGS			
		Total	Mean	Minimum	Maximum
<i>T. sinensis</i>					
Bronx .....	67	17,493	261.1 $\pm$ 3.5	154	338
" .....	59	15,439	261.7 $\pm$ 3.7	154	338
Ocean View .....	53	15,689	296.0 $\pm$ 5.7	172	423
" .....	51	15,211	298.2 $\pm$ 5.7	172	423
<i>T. angustipennis</i>					
Ocean View .....	88	20,988	238.5 $\pm$ 3.9	36	373
" .....	84	20,264	241.2 $\pm$ 3.7	129	373

### OBSERVATIONS AND REMARKS

*Number of Eggs.*—Records of the number of eggs present in the oothecae examined are summarized in Table I.

Each lot of oothecae is listed twice. In each the results first given are based upon the entire lot, those on the second line upon the oothecae from which nymphs emerged. It is evident that by either selection nearly identical means are obtained.

Comparison of these results with those previously published (Fox, 1939a, Table I) shows close agreement between comparable lots. However, contrary to the negative view favored in the writer's earlier paper, the difference between the mean of *T. sinensis* from the Bronx and that of the same species from Ocean View is now found to be statistically significant, being considerably more than thrice its probable error. Since in the earlier work the significance of the difference was uncertain and since the figures here published are based upon a much larger sample from Ocean View, the conclusion seems warranted that

oothecae of *T. sinensis* from the last named locality contain significantly larger numbers of eggs than those from the Bronx section of New York City. Whether this difference, apparently correlated with latitude, would hold if material from a wider range of localities had been selected is a query incapable of a definite answer in the light of the present evidence, but the result suggests at least the probability of an increased egg production in the more southern portions of the insect's range.

Of the 14 oothecae from which no nymphs emerged, 7 contained eggs which showed no certain traces of development. Of these, six belonged to *T. sinensis*, the other to *T. angustipennis*. Among them only a single ootheca from the Bronx was obviously abnormal, with the inner capsule unformed and the eggs distributed promiscuously through the general matrix. In the remaining oothecae, from which nymphs failed to emerge, only a limited proportion of the eggs showed signs of development.

No change from that previously recorded was noted in the number of eggs in the oothecae of *T. sinensis* from the Bronx. However, in the material of both species from Ocean View a noteworthy extension of the extremes was shown. In the earlier sample of *T. sinensis* from that locality the number of eggs per ootheca extended from 230 to 351, in the more recent sample from 172 to 423. In *T. angustipennis* the observed extremes in the older series were 93 and 335, in the present series 36 and 373.

*Length of the Period of Incubation.*—The only part of the period of incubation here taken into consideration is the time between the date when the oothecae were placed under observation and that on which nymphal emergence began. The full length of the developmental period was naturally indeterminable, since the oothecae when collected had already undergone some development previous to the advent of cold weather. Limiting consideration to oothecae which while under observation were continuously exposed to developmental temperatures, the average length of the period of incubation in 45 oothecae of *T. sinensis* from Ocean View was 29.7 days, with a minimum of 8 and a maximum of 48 days. There was a wide gap in this lot between the minimum, which was limited to a single ootheca, and the next following emergences which occurred on the 19th day (Table II). After the latter, emergence was of almost daily occurrence until the 41st day. In another lot of 59 oothecae of the same species from the Bronx the average was 34.4 days, with extremes of 30 and 50 days. In this case emergence was general between 30 and 44 days. In *T. angustipennis* a series of 50 oothecae gave 45.6 days as the average length, with a range from 39 to 64 days and emergence of general occurrence between the initial and 51st day.

Since the lot of oothecae of *T. sinensis* from Ocean View and the series of *T. angustipennis* were placed under observation simultaneously and hence developed under essentially identical conditions, it is clear that in the former development proceeds far more rapidly than in the latter. Fully 73 per cent of the oothecae of *T. sinensis* had yielded nymphs by the time emergence began in the other species. According to the field observations of the writer, adults of both species appear at



Ocean View in late August or early September and oviposition in both starts shortly thereafter. It, therefore, seems likely that the observed difference in the rate of development of their eggs is of genetic origin. However, the possibility also exists that it may have arisen in part from the conditions of the experiment. These, while evidently congenial to development in *T. sinensis*, were definitely less favorable to *T. angustipennis*, as is evidenced by the reduced emergence obtained in the latter, a subject more fully treated in a later section of this paper. At this point it suffices to state that a condition readily endurable by some species may prove relatively harmful to others and that one way in which the resultant injury may be expressed is in retarded embryonic development.

TABLE II

Correlation of Egg Content of Oothecae of *Tenodera* and Length of Period of Incubation

Period of Incubation (Days)	<i>T. sinensis</i> (Bronx)				<i>T. sinensis</i> (O V)				<i>T. angustipennis</i>			
	Number of Oothecae	Eggs per Ootheca			Number of Oothecae	Eggs per Ootheca			Number of Oothecae	Eggs per Ootheca		
		Mean	Min	Max		Mean	Min	Max		Mean	Min	Max
5-9	0				1	331 0			0			
10-14	0				0				0			
15-19	0				3	331 3	216	423	0			
20-24	0				6	354 0	329	411	0			
25-29	0				11	318 1	236	399	0			
30-34	37	266.1	154	338	12	307 6	222	378	0			
35-39	13	265 2	208	334	8	258 3	195	302	1	266 0		
40-44	8	239 3	208	292	2	257 0	177	337	19	276 4	129	373
45-49	0				2	180 5	172	189	27	231.6	139	306
50-54	1	232 0			0				1	167 0		
55-59	0				0				0			
60-64	0				0				2	166 0	143	189
Total	59				45				50			

*Correlation between Egg Content of Oothecae and the Length of the Period of Incubation.*—The data bearing upon this point, which are taken exclusively from material kept continuously at room temperature, are summarized in Table II.

These results indicate a general inverse relation between the egg content of the oothecae and the length of the period of incubation. The explanation doubtless lies in the varying age of the oothecae when collected. In oothecae formed early in the season development would progress farther before the onset of winter than in those formed at a later period and would, therefore, hatch sooner when brought indoors. This inference is substantiated by the finding of fully formed nymphs, apparently about to hatch, in a few oothecae collected in mid-winter, when no trace of development was discernible to the unaided eye in the remaining oothecae. It was doubtless an ootheca in this condition which is shown in Table II as giving nymphal emergence within nine

days following its transfer to the laboratory. The results tabulated in Table II therefore suggest that, in general, the higher numbers of eggs pertain to the earlier produced oothecae, the reduced numbers to those later formed.

*Nymphal Production and Emergence.*—The data on the number of nymphs formed and the proportion emerging in the newer lots of oothecae are summarized in Table III. The tabulated figures are based solely upon material which was kept continuously at room temperatures.

In the writer's earlier paper the failure of part of the nymphs to emerge from the oothecae was noted. The number emerging is, therefore, usually less than the number formed and, even among them, some individuals are often found moribund or otherwise defective and

TABLE III

Nymphal Production and Emergence in Oothecae of *Tenodera*, 1938

LOCALITY	NUMBER of OOTHECAE	NYMPHS				
		Number Formed	Number Emerging	EMERGENCE		
				Total (Per Cent) <sup>2</sup>	Viable (Per Cent) <sup>2</sup>	Range of Viable (Per Cent) <sup>2</sup>
<i>T. sinensis</i>						
Bronx	59	13,956	13,207	94.6	93.8	22.0 — 100.0
Ocean View	45	12,844	12,084	94.1	93.5	43.6 — 100.0
<i>T. angustipennis</i>						
Ocean View	53	12,294	9,897	80.5	75.6	0(30.3) — 96.7

<sup>2</sup>In terms of the number formed.

incapable of survival. In Table III nymphs which on emergence appeared to be normal are termed viable and their percentage is listed separately from that of the total number emerging.

It is evident from the results that emergence and potential survival were considerably higher in *T. sinensis* than in *T. angustipennis*. The difference is close to that previously reported. In the earlier study (Fox, 1939a) the emerging nymphs of *T. sinensis* comprised from 96 to 97.6 per cent of those formed, while in *T. angustipennis* they comprised only 79.8 per cent. In the newer material the corresponding figures were from 94.1 to 94.6 per cent in *T. sinensis* and 80.5 per cent in *T. angustipennis*.

In the writer's former paper evidence was presented which suggested that the lower emergence in *T. angustipennis* might have resulted from exposure of some of the oothecae to cold at a critical stage of embryonic development. It was surmised that under like conditions the proportion of emerging nymphs in *T. angustipennis* would probably equal that obtained in *T. sinensis*. The newer evidence, which was obtained under similar conditions in both species, fails to substantiate that view and instead suggests that some experimental condition

capable of being withstood by the one species without perceptible injury may be definitely less favorable for the other.

The factor responsible for the difference noted in the nymphal emergence of the two species is probably traceable to the relative effectiveness of their oothecae in conserving the moisture content of the enclosed eggs. The ootheca of *T. sinensis* is remarkable for the unusual thickness and highly vesicular texture of its cortical covering, which is almost impervious to water (Weiss, 1914). In striking contrast, the same layer in *T. angustipennis* is thin and homogeneous. It therefore seems likely that, under conditions where evaporation is not prevented, the eggs of the former would be more securely protected against loss of the moisture essential for optimal development than would those of its congener.

*Nymphal Emergence in Dry and Wetted Oothecae.*—In view of the presumptive importance of evaporation in influencing nymphal emergence, a test was made in which, as earlier mentioned, emergence from oothecae kept permanently dry could be compared with that from others regularly wetted each week. The result showed that the difference in treatment had no effect upon emergence in *T. sinensis*, where the viable nymphs in the wetted oothecae formed  $93.9 \pm 1.3$  per cent of the total produced, compared with  $93.1 \pm 1.9$  per cent in the dry lot. In *T. angustipennis* an apparent improvement was empirically indicated, the viable nymphs in the moistened oothecae forming  $80.0 \pm 3.2$  per cent of the total, in the dry  $71.6 \pm 3.2$  per cent. However, in this species the range of variation in the emergence of individual oothecae was very wide and essentially identical in both lots, in positive cases ranging from 31.9 to 96.5 per cent in the wetted and from 30.3 to 96.7 per cent in the dry oothecae. This, along with the magnitude of the probable errors, precludes attaching statistical significance to the apparent difference.

Because of the inconclusive nature of the evidence from this test, it can scarcely be regarded as furnishing an adequate disproof of the view that the key to improved nymphal emergence in *T. angustipennis* lies in conserving the moisture content of the oothecae. It may well be that the brief wetting to which the oothecae were subjected did not allow enough moisture to soak through the surface to replace that previously lost and hence may have served as, at most, but a temporary check on continued loss through evaporation.

*Emergence as Affected by Length of Period of Incubation.*—Since experimental evidence no more conclusive than that just cited is at present available as a criterion of loss of moisture through evaporation as a potent factor in conditioning nymphal emergence, the writer has analysed the data of both the earlier and the present series of experiments to determine how far emergence was affected by the length of the period of incubation. The amount of moisture lost from this source is obviously a function of time of exposure. It is, therefore, a plausible inference that the longer the time required for incubation the greater would be the reduction in the proportion of emerging nymphs. The result of the analysis of the data in question was definitely negative as regards *T. sinensis*, a not unexpected outcome in view of the special structure of the ootheca in that species. In *T. angustipennis*, however,

some indications of a decreased emergence with a prolonged period of incubation were obtained. In the series of the latter species collected in 1937 the average emergence in 24 oothecae with an incubation period of from 40 to 49 days was  $92.0 \pm 1.39$  per cent, in 22 others with the same period ranging from 50 to 59 days it was  $82.7 \pm 2.24$  per cent, and in a third lot of 20 oothecae, where the period extended from 60 to 69 days, it was  $61.7 \pm 2.78$  per cent. In the series of the same species obtained in 1938 the average emergence in 70 oothecae with an incubation period of from 40 to 49 days was  $79.2 \pm 2.01$  per cent. In the remaining groups of the latter series only five oothecae were represented and, although they gave emergences in accord with hypothetical expectation, the size of the samples leaves their statistical significance uncertain. The results with *T. angustipennis*, while perhaps not entirely conclusive, thus favor the view that the longer the period of incubation the less the percentage of emergence and thereby suggest progressive desiccation as the probable determining factor. However, there is need in this case for further study and it is hoped that future experimental investigation may throw clearer light upon the problem.

*Effect upon Nymphal Emergence of Temporary Inhibition of Development by Cold.*—It was mentioned earlier that part of the series of oothecae from Ocean View was temporarily stored in a refrigerator. Comparison of the results obtained with these oothecae with those of the check lot indicates a negative effect of the temporary inhibition of development by cold upon subsequent nymphal emergence. In the cold-exposed set of *T. sinensis* viable nymphs formed 91.0 per cent of the total number produced, compared with 93.1 per cent in the check, while in *T. angustipennis* the corresponding figures were 68.4 per cent in the cold-exposed set and 71.6 per cent in the check. The difference in each case is obviously too small to be significant. The period during which the oothecae were stored in the refrigerator varied from 34 to 52 days, although a few oothecae of *T. sinensis* were removed after only 8 days. No evidence was obtained to show that within these limits the precise duration of the storage made any difference in the extent of nymphal emergence.

*Diurnal Periodicity in Emergence.*—In the writer's earlier paper it was stated that nymphal emergence in both species of *Tenodera* exhibits the same general periodicity that Rau and Rau (1913) had described in *Stagmomantis*, the main difference being its extension in the former throughout the entire forenoon instead of terminating about 9 A. M. The data now available confirm the earlier observations insofar as they show emergence to be far more frequent in the forenoon than at other times during the day. However, in the more recent work, some exceptions to this rule were found, so distributed in their occurrence as to indicate that emergence may occur at almost any time. In some instances emergence occurred long after dark, the latest observed being about 11 P. M.

*Infestation by Podagrion mantis Ashmead.*—No instances of infestation of oothecae by this egg parasite were observed in this further study of *Tenodera* oothecae (Fox, 1939b).

## SUMMARY

1. In a continued study of oothecae of two species of mantids of the genus *Tenodera*, based upon material collected, as before, in the Bronx section of New York City and at Ocean View, New Jersey, the average number of eggs per ootheca in each case was not significantly different from that previously recorded. Contrary to the earlier expressed view, the results in this later study strongly support the view that the difference between the average of *T. sinensis* from the Bronx and that of the same species from Ocean View is statistically significant and thus suggestive of a variation in the average egg content of the oothecae dependent upon differences in the latitudinal range of the species.

2. The range of variation in the egg content of oothecae of *T. sinensis* from the Bronx falls well within that earlier recorded, but in material of that species and of *T. angustipennis* from Ocean View a noteworthy extension of the range was shown. In the former the range was from 172 to 423, in the latter from 36 to 373.

3. The time required for incubation of the eggs in oothecae collected outdoors in winter averages considerably less in *T. sinensis* than in *T. angustipennis*. The difference is probably genetic, but the suggestion is made that environmental effects may also play a part, owing to the cortical covering in one species presumably serving as a more efficient protective device against progressive desiccation than in the other.

4. The number of eggs per ootheca shows an inverse correlation with the length of the period required for incubation under indoors conditions. The factor suggested as responsible is the seasonal sequence of deposition of the oothecae, the earlier oothecae having a higher egg content than those deposited later.

5. The proportion of nymphs emerging from the oothecae showed the same general disparity between the two species as was previously recorded, although both were reared under essentially identical conditions in the more recent study. The result thus fails to substantiate the earlier drawn inference that the lower emergence in *T. angustipennis* came from exposure of some of the oothecae of that species to cold at a critical stage in embryonic development, and instead suggests that experimental conditions apparently favorable for optimal emergence in one species may prove definitely less favorable in a different species.

6. The factor tentatively suggested as responsible for the observed disparity in nymphal emergence of the two species is the relative effectiveness of their oothecae in conserving the moisture content of the enclosed eggs, as indicated by differences in the thickness and texture of the cortical coats of the oothecae in the two species.

7. Nymphal emergence in oothecae wetted at weekly intervals, compared with that in others kept permanently dry, was inconclusive as a test of the importance of moisture conservation in determining nymphal emergence, although in *T. angustipennis* an apparent improvement was indicated in the moistened sample, but of too small a margin to be acceptable as conclusive.

8. The influence of the length of the period of incubation upon the extent of nymphal emergence was studied as a partial test of the hypothesis of progressive desiccation as the determining factor in the

potential survival of the emerging nymphs. The result was negative in *T. sinensis*, but in *T. angustipennis* some evidence was found of a decreased emergence with a lengthening of the period required for incubation.

9. Diurnal periodicity in nymphal emergence is indicated as generally prevalent during the forenoon, as previously observed, but some exceptions to the rule show that emergence may occur at other times during the day and in some instances even long after nightfall.

10. No cases of parasitism by *Podagrion mantis* were observed in the newer series of oothecae.

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**A STUDY IN NEOTROPICAL PSELAPHIDAE**, by ORLANDO PARK. 1942. Pages x and 403, 21 plates 7<sup>1</sup>/<sub>2</sub> x 10<sup>1</sup>/<sub>4</sub> inches, cloth bound. Published as Studies in the Biological Sciences and Medicine, No. 1, by NORTHWESTERN UNIVERSITY. Price, postpaid, \$7.50.

Professor Orlando Park has done much research on insects and other animals that live with ants and termites. "This volume is not a monograph. It is a summary of data preparatory to monographic study. The author has attempted to co-ordinate and add to the information on the Pselaphidae which inhabit the American tropics."

As a general introduction seven pages are given to generalities on the two types of life, that of the mould species and the habits of the forms which inhabit ant nests. In this part are given many hints for finding pselaphids in the field and methods of collecting. They feign death, look like particles of the soil and are generally difficult. Thus we know so little about them but many of the larger nests of common ants accommodate such guests in considerable variety.

Pselaphids are so small, 0.6-4.0 mm. in length, that they require special techniques of preservation and preparation for accurate description. Five pages cover these problems. Nineteen pages are devoted to a detailed guide to their taxonomic morphology, the curious characters that occur in various groups of genera. Some of this work uses the compound microscope up to several hundred diameters magnification. Further, "there is no qualitative criterion the application of which will separate all pselaphids from all staphylinids," again they are difficult.

Pages 31 to 358 are devoted to the seventeen tribes of Pselaphidae found in the Western Hemisphere, a tentative taxonomic treatment as a monograph cannot be written until much more is known of types, topotypes and material from the present unexplored areas. Fifty new species are described.

Pages 360 to 380 are titled "Zoogeography" and give comparisons of various pselaphid faunas, one with another, with suggestions as to relationships.

This large volume is a working manual for future students of Pselaphidae. It gives the writer a thrill to find such large scale help given out generously to other possible students. The constant teaching in several departments of entomology against hoarding in taxonomy at times appears to have had little effect as hoarding is a biproduct of collecting fragile material. But with the recent realization of the enormous numbers of undescribed inconspicuous insects we may lose some of the undesirable features of past taxonomic technique.—C. H. K.

## TWO NEW CHRYSOBOTHRIS

(Buprestidae: Coleoptera)

J. N. KNULL,

The Ohio State University,  
Columbus, Ohio

### *Chrysobothris culbersoniana* n. sp.

*Male*.—Form, size and color of *C. deleta* Lec., piceous, with bronzy tinge, more strongly shining beneath; pubescence moderate on head, pronotum, ventral surface and legs, sparse on elytra.

Head bronzy, convex, longitudinal carina on vertex joining an obtuse V on front; front with two irregular smooth callosities; clypeus broadly emarginate; surface coarsely punctate; antennae feebly narrowed to apex, serrate from the fourth joint, third segment longer than fourth, outer segments wider than long.

Pronotum twice as wide as long, widest in front of middle, wider at base than at apex; sides strongly rounded; anterior margin slightly sinuate, median lobe broad; basal margin strongly emarginate each side, median lobe broadly rounded; disk convex; surface coarsely punctured, smooth callosities irregular, one median and two lateral ones in front being most prominent. Scutellum triangular, depressed.

Elytra at base wider than widest part of pronotum; sides subparallel to middle, widened back of middle, then converging to rounded apices; lateral margins serrulate; basal depression broad; surface irregularly punctate, each elytron with four irregular costae interrupted by two foveae, costae more prominent posteriorly.

Abdomen beneath densely, finely punctured, each sternite with a smooth callosity on each side near lateral margin, last visible sternite broadly emarginate, lateral margin serrulate. Prosternum without a lobe. Anterior femur with an acute tooth. Anterior tibia arcuate, a small tooth near apex, other tibiae straight.

Length 6.5 mm.; width 2.5 mm.

Described from two male specimens collected in Culberson Co., Tex., May 10, 1941, by D. J. & J. N. Knull, in collection of the writer.

This species should be placed near *C. deleta* Lec. according to Fisher's arrangement<sup>1</sup> of the genus. Lack of pubescence on elytra and prosternal lobe separate it from the closely allied forms.

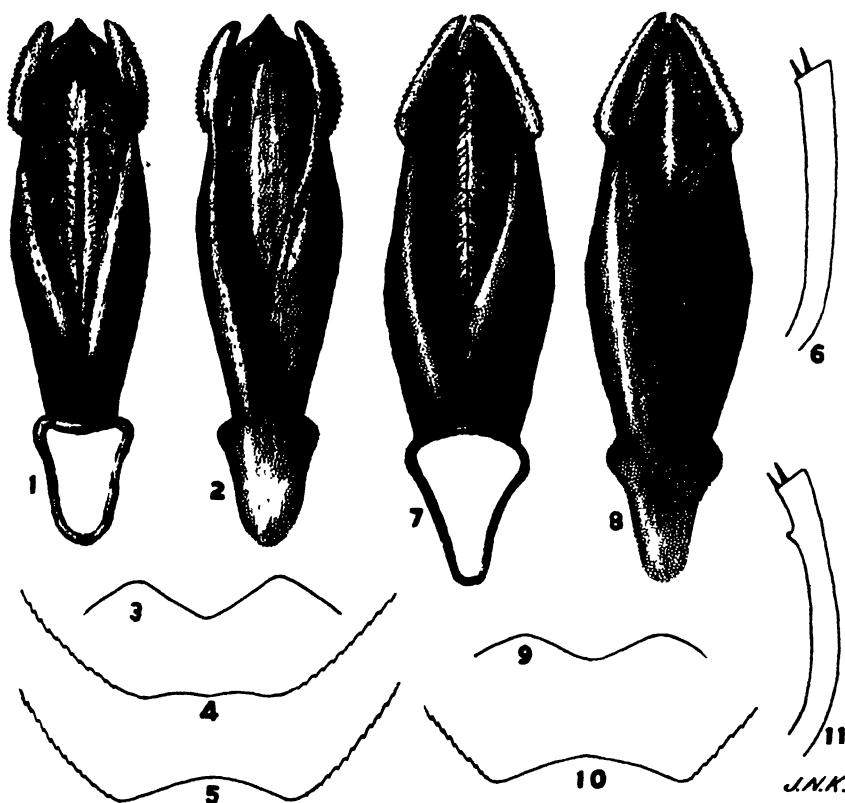
### *Chrysobothris crandalli* n. sp.

*Male*.—Resembling *C. deserta* Horn in size and form. Convex, brownish cupreous above; foveae of elytra and ventral surface cupreous; front brilliant green; occiput and apical margin of pronotum bright cupreous; pubescence of entire insect well indicated.

<sup>1</sup>W. S. Fisher, U. S. D. A. Misc. Pub. 470, pp. 1-274, 1942.

Head convex, a carina on occiput, a small smooth callosity on front on each side; surface densely punctate, pubescence long; clypeus broadly emarginate, antennae short, outer segments compact, wider than long, third joint not as long as the two following joints together.

Pronotum wider than long, wider at base than at apex, widest in middle; sides broadly rounded; anterior margin sinuate, median lobe rounded; base more strongly emarginate, median lobe broadly



*Chrysobothris crandalli* n. sp. 1. Dorsal view of male genitalia. 2. Ventral view of male genitalia. 3. Clypeus. 4. Last visible abdominal sternite of female. 5. Last visible abdominal sternite of male. 6. Anterior tibia of male.

*Chrysobothris culbersoniana* n. sp. 7. Dorsal view of male genitalia. 8. Ventral view of male genitalia. 9. Clypeus. 10. Last visible abdominal sternite of male. 11. Anterior tibia of male.

rounded; disk convex, a large smooth callosity in each side in front of middle; surface very coarsely punctate, pubescence long. Scutellum triangular, glabrous.

Elytra at base wider than widest part of pronotum, widest back of middle; sides nearly parallel near base, expanded behind middle, then arcuately rounded to rounded apices; lateral margins serrate



posteriorly; disk convex, basal depression well marked, humeral depressions slight; surface scabrously punctate, clothed with short pubescence; each elytron with four longitudinal costae, interrupted by two foveae.

Abdomen beneath densely punctate, lacking lateral callosities; last visible sternite broadly emarginate, lateral margin serrulate. Prosternum clothed with long pubescence, anterior margin with broadly rounded lobe. Anterior femur with acute tooth, lacking serration. Anterior tibia straight, lacking tooth near apex; other tibiae straight.

Length 9 mm.; width 3.4 mm.

*Female*.—Differing from male by entire head being brilliant cupreous; last visible abdominal sternite slightly bisinuate at apex.

Holotype labeled Phoenix, Ariz., May 9, 1925, R. H. Crandall collector; allotype May 25 of same year and collector, also paratypes from the same locality May 9 and 23. One from Sabino Canyon, Ariz., May 11, 1938. F. H. Parker collector. Type material in collection of writer.

The species resembles *C. deserta* Horn and should probably stand next to it in Fisher's arrangement of the genus. Due to lack of tooth on the anterior tibia it can be distinguished from its allies.

**BIOCHEMISTRY AND MORPHOGENESIS**, by JOSEPH NEEDHAM, 1942. Pages xvi and 787, 328 text figs., 35 pls. Size 7x10 inches. Published by CAMBRIDGE UNIVERSITY PRESS, Cambridge, England, and THE MACMILLAN CO., 60-Fifth Ave., N. Y. Price \$12.50.

This handsome volume summarizes all the facts of embryology as established in recent years by the research in the field of experimental embryology. Doctor Needham is an organic chemist (author of *Chemical Embryology*, 3 vols., 1931) as well as a student of embryology. This volume reflects his dual approach to the problem of morphogenesis. Spemann, the Mangolds, Paul Weiss, R. G. Harison and other experimentalists have described the functions of parts of the growing embryo with here and there light on the chemical background of the processes. Needham organizes such material scattered through many papers and volumes, adds to each process discussed his own work in the chemistry of the many processes and gives embryologists a broad organized view of the chemical processes involved in the developing embryo.

There are nineteen pages of indices. The volume is organized in three parts: Part I. The Morphogenetic Substratum; Part II. The Morphogenetic Stimuli; and Part III. The Morphogenetic Mechanisms. The three parts of the Table of Contents list six pages of subheads.

Doctor Needham is a lucid writer on intricately involved subjects. In this work he uses many illustrations and diagrams which help the reader keep oriented. But he has to deal with three dimensions, with macro-, micro- and chemical units. It becomes complex but is always interesting to the reader whose curiosity leads him into the processes and theories of embryonic development.

Biochemistry and Morphogenesis is as sound a volume as hard work and present knowledge of this field can produce. Apparently no part has suffered from hurried writing or has been glossed over. The reviewer found some basic facts about the insect egg that he had not picked up before in the scattered literature. We admire any man who can be so commanding in a biological field and so productive.—C. H. K.

# THE ISOLATION OF A RED-FLUORESCENT PIGMENT, LAMPYRINE, FROM THE LAMPYRIDAE<sup>1</sup>

ROBERT L. METCALF,

Cornell University,  
Ithaca, N. Y.

The rose coloration of certain areas of the pronotal disc is a familiar taxonomic character of the coleopterous family, Lampyridae, and is mentioned in almost all descriptions of the adult members of this group. There are, however, no indications of the physical or chemical nature of this color. Observation of the pronotal pigment of *Pholinus marginellus* with the fluorescent microscope showed that the pigment fluoresced a beautiful rose-red under the influence of ultra-violet irradiation. As red fluorescence is most infrequently encountered among biological materials, the material appeared to be of sufficient interest to warrant an investigation.

It was found that in *P. marginellus* the pigment appeared in the adipose tissue under the pronotum, and was spread subcutaneously through the meso- and meta-thoraces into the abdomen where it was encountered immediately beneath the cuticular layers of the dorsal abdominal wall. By far the greatest concentration, however, was in the male gonads, which were a deep rose, almost red color. When examined with the fluorescence microscope, the gonads presented a striking appearance. The yellowish tissue of these organs had an intense blue-violet fluorescence, through which was sprinkled tiny bright red fluorescent particles. Bugnion (1929) has confirmed the observation on the color of the male gonads in other genera. He states that the developing male gonads in *Lampyris*, *Phausis*, and *Pelania* are rose colored, in fresh tissue.

The male gonads are spheroidal bodies about 0.5 to 0.6 mm. in diameter and consist of a number of chambers or spermatid tubes, separated and surrounded by epithelial tissue, the whole being covered by a peritoneal sheath. Upon examination under high magnification, the color is seen to reside in very many tiny spherites, from 0.0007 to 0.003 mm. in diameter which are pinkish in color. The spherites are confined to the epithelial tissue under the peritoneal sheath of the testis. These spherites showed pronounced double refraction, with characteristic uniaxial interference figures, when examined with the polarizing microscope. The source of the pigment elsewhere in the insects' bodies was found in similar spherites imbedded in subcutaneous tissue.

When dried rapidly, the pigment apparently was very stable, appearing in the bodies of insects collected over 60 years ago, but in a moist state, the material was rapidly decomposed, probably by enzyme action. Dead insects that were left over night in a closed, moist bottle showed no trace of the pigment the next day. The pigment was very

<sup>1</sup>Contribution from the Division of Insect Physiology, Department of Entomology, Cornell University, Ithaca, N. Y.

insoluble in water, methyl and ethyl alcohols, ether, chloroform, carbon bisulfide, acetone, formaldehyde, pyridine, and acetic acid. It was soluble in 5% (and stronger) hydrochloric acid forming a faintly rose-colored solution which fluoresced in a bright orange band from 655 to 563 mu., with maxima at 635 and 600 mu. The addition of 30% potassium hydroxide solution to the pigment also dissolved it, turning it a dull blue, and shifting the fluorescence spectrum to a fiery red band, 672 to 622 mu., with a maximum at 650 mu., which faded slowly upon irradiation, to a yellow green. Ammonium hydroxide produced the same effect as potassium hydroxide, while concentrated nitric acid

TABLE I  
Red Fluorescent Biochemical Substances, Showing Wave Lengths of  
Fluorescent Spectra<sup>2</sup>

COMPOUND	SOURCE	SOLVENT	WAVE LENGTH OF FLUORESCENT BAND IN MU
lampyrine	<i>Photinus marginellus</i>	HCl	655-563
chlorophyll a	Green plants	Ethyl ether	680-650
chlorophyll b	" "	" "	655-640
chlorophyll c	" "	" "	637-627
protochlorophyll	" "	" "	633-620
bonelline	<i>Bonellia viridis</i>	Alcohol	681-666 655-630 617-607
pheophytin a	Plant pigments	Ether	747-713 696-666
pheophorbides a	" "	Alcohol	Max 730 670
pheophorbides b	" "	"	Max 725 658
phylloerythrin	" "	Chloroform	650-636
phycoerythrin	" "	Water	585-572
phycocyanin	" "	"	653-642
protoporphyrin	Animals	HCl	663-647 609-598
uroporphyrin	"	"	660-645 601-592
coproporphyrin	"	"	659-645 601-589
hematoporphyrin	"	"	654-646 602-592
mesoporphyrin	"	"	657-642 599-588
etioporphyrin	"	"	656-641 598-589
porphine	"	"	Max 648 604
oxypenicilliospine	<i>Penicillioopsis clavariaeformis</i>	Alcohol	649-635 612-605 599-590
hyperane	<i>Hypericum perforatum</i>	"	Similar to above
lanigerine <sup>3</sup>	<i>Eriosoma lanigerum</i>	"	Max 634 608 591 561 530 499
strobilime <sup>3</sup>	<i>Pineus strobi</i>	"	Similar to above

<sup>2</sup> Dhere, 1939a, with exception of lampyrine which is original observation

<sup>3</sup> Dhere 1939 b

completely destroyed the color and the fluorescence. Diazotization with nitrous acid had no effect on the color or fluorescence, nor did reduction with sodium hydrosulfite or oxidation with hydrogen peroxide. There was no color reaction with Ehrlich's diazo reagent, with aqueous ferric chloride, with the murexide test, and with reduction by zinc and hydrochloric acid.

The absorption spectrum of the material in dilute hydrochloric acid, showed a strong absorption band between the yellow and green at 565 mu.

By dissolving macerated gonadal tissue in 5% hydrochloric acid, warming gently, and allowing to cool gradually, tiny crystals, appar-

ently bipyrimidal, showing salmon pink fluorescence and double refraction with intense pleochroism were obtained. These melted at 315°C and presumably represented the pure compound. Although the gonads were dissected from more than 200 individual insects, the amount of pigment obtained was insufficient to permit a quantitative chemical analysis.

By a consideration of the previously known red fluorescent biological materials and their solubilities it becomes evident that the pigment differs widely from any hitherto described. (See Table I). As it is a red pigment it can scarcely be related to the chlorophylls and their derivatives which are green compounds and are ether and alcohol soluble. The porphyrins which possess similar absorption spectra, are soluble in organic solvents, have several fluorescent bands, and give characteristic color reactions with Ehrlich's diazo reagent. The polyhydroxyanthraquinones, which comprise a number of insect pigments, in the aphids and coccids, also have fluorescent spectra of more than one band and are alcohol soluble. In its solubilities, lampyrine somewhat resembles the acid and alkali soluble pterines, widely distributed pigments in the Lepidoptera. Schöpf and Becker (1936) have described several new fluorescent pterines: erythropterine, orange-red with brown fluorescence; xanthopterine, white with green-yellow fluorescence; and chrysopterine, orange with blue-violet fluorescence. These compounds, however, gave a definite murexide reaction, while lampyrine did not.

As the pigment is easily detectable in preserved specimens by examination under ultra-violet light, a survey of the Lampyridae and neighboring families was made to ascertain the distribution of the pigment throughout the family. Of 45 species examined in the collections of Cornell University and of the University of Illinois, the presence of the pigment was detected in 43. These are listed below:

<i>Lucidota atra</i>	<i>Photinus lineellus</i>
<i>L. tarda</i>	<i>P. ardens</i>
<i>L. punctata</i>	<i>P. punctulatus</i>
<i>Ellychnia flavicollis</i>	<i>P. umbratus</i>
<i>E. facula</i>	<i>P. dimissus</i>
<i>E. californica</i>	<i>P. pyralis</i>
<i>E. corrusca</i>	<i>P. vittatus</i>
<i>E. autumnalis</i>	<i>P. marginellus</i>
<i>E. lacustris</i>	<i>P. dubiosus</i>
<i>Pyropyga fenestralis</i>	<i>P. scintillans</i>
<i>P. nigricans</i>	<i>Pleotomus pallens</i>
<i>P. decipiens</i>	<i>Photuris frontalis</i>
<i>P. minula</i>	<i>Photuris divisa</i>
<i>P. indicta</i>	<i>Lampyris rufa</i>
<i>Pyractomena angulata</i>	<i>Aspidosoma buyssoni</i>
<i>P. galeata</i>	<i>Callopisma boreconia</i>
<i>P. borealis</i>	<i>Microphotus angustus</i>
<i>P. ecostata</i>	<i>Luciola parvula</i>
<i>P. lucifera</i>	<i>L. vitticollis</i>
<i>P. angustata</i>	<i>L. mauritanica</i>
<i>Photinus consanguineus</i>	

No trace of the pigment could be found in *Tenaspis angularis*, of which a single specimen was examined, and in the common species *Photuris pennsylvanica*. It is quite possible that examination of fresh material of these two species would reveal the presence of the pigment, as it was occasionally not visible in certain specimens of species known to contain it, the postmortem treatment of the specimen apparently being an important factor. No trace of the pigment was found in a large number of species of the closely related families of Phengodidae, Cantharidae, or Lycidae.

In species where both males and females were at hand, *Photinus consanguineus* and *P. scintillans*, the pigment was abundant in both sexes. The pigment occurred plentifully in both luminous and non-luminous species and was apparently not a metabolite of the luminous processes.

The exceedingly wide and exclusive distribution of lampyrine in the Lampyridae would seem to indicate the presence of a peculiar type of metabolism, which is even more fundamental to the members of this singular group, than their well known property of luminescence. The author has no explanation to offer for the apparent formation of this material in the gonads, but feels that this subject offers an interesting field for future investigation.

### SUMMARY

The isolation and crystallization of a pink, red fluorescent, acid and alkali soluble pigment, apparently new to science, is described. This material occurs, so far as is known, only in members of the coleopterous family Lampyridae, among which it is of wide distribution. It is apparently not closely identified with any of the known classes of insect pigments.

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# SOME RESPONSES OF THE MALARIA MOSQUITO TO LIGHT<sup>1</sup>

WILLIAM R. HORSFALL,  
University of Arkansas

Methods of accurately sampling relative densities of species in local mosquito populations often trouble persons interested in mosquito abatement. With the present expansion of interest in reducing annoyance from mosquitoes in many widely distributed areas, evidence relating to the limitations of the methods is needed. At the present time, no one of the sampling devices alone is generally acceptable for accurately stating the quantitative relations of species in a local mosquito population, but those with light as the attracting principle have been widely used in the United States.

In recent years, the New Jersey style light trap (8) has been standardized in construction and has been in use in different parts of the country (5, 7, 9, 3). This device has proved useful as a means of comparing trap collections of pest species and relative human annoyance in New Jersey (2) where the longest continuous series of collections has been made. As a means of sampling relative populations of species, this trap has been criticized by some observers; for example, its dependability is considered uncertain in situations where anophelines are present according to Herms and Gray (4). These writers say there are still too many unknown factors affecting the reactions of mosquitoes to light and other stimuli to place much confidence in either the qualitative or quantitative aspects of the catches.

A New Jersey trap with minor modifications has been operated at the Rice Branch Experiment Station in the rice region of Arkansas where large populations of mosquitoes occur. The attracting element was a 40-watt, frosted, mazda, electric bulb operating on a 110-volt, alternating-current circuit. The trap was suspended so that the light radiated in all horizontal directions from an elevation of 5½ feet above the ground. There were no adjacent competitive lights. A part of the time it was operated in conjunction with an apparatus for automatically changing the collecting jars at hourly intervals (6). Three years of collecting show certain consistent responses of the malaria mosquito to light.

The mosquito population in the region is composed of both flood-water (*Psorophora*) and permanent-water (*Anopheles* and *Culex*) species. The *Psorophora* emerge from a rice field during a short interval beginning within a few days after flooding (5), and the relative numbers trapped during any one night are determined for the most part by the acreage being flooded and by the proximity of that acreage to the trap. To a lesser degree, direction and speed of the air drift determine the numbers trapped. Records on these species show nightly fluctuations sometimes

<sup>1</sup>Research Paper No. 752, Journal Series, University of Arkansas. Approved for publication by the Director of the Arkansas Agricultural Experiment Station.

TABLE I  
 Relation Between Phase of Moon and Hourly Attraction of *Anopheles quadrimaculatus* to Light at the Rice Branch Experiment Station  
 1939—1941

Hour	COLLECTIONS OF MOSQUITOES AT TIME OF NEW MOON					COLLECTIONS OF MOSQUITOES AT TIME OF FIRST QUARTER		COLLECTIONS OF MOSQUITOES AT TIME OF FULL MOON					COLLECTIONS OF MOSQUITOES AT TIME OF LAST QUARTER				
	1939	1940	1941	Total* 3 yrs.	Per Cent	1941	Per Cent**	1939	1940	1941	Total* 3 yrs.	Per Cent	1940	1941	Total*** 2 yrs.	Per Cent	
																	Num- ber
8	20	5	71	96	1	7	.....	6	2	.....	8	4	25	3	4	33	4
9	201	30	264	495	7	58	4	25	3	.....	32	15	3	4	45	91	13
10	132	37	404	573	7	64	4	35	1	.....	44	21	1	8	51	91	13
11	243	49	888	1179	15	165	11	18	.....	4	22	11	.....	40	84	91	12
12	262	99	514	875	11	234	16	12	2	.....	18	9	2	4	40	84	12
1	421	91	482	994	13	314	22	7	1	.....	4	5	2	4	42	78	17
2	443	68	672	1183	15	390	25	22	1	.....	11	16	1	3	94	138	19
3	770	72	754	1596	20	175	12	8	1	.....	11	34	1	11	22	51	73
4	264	49	502	815	10	67	5	10	5	.....	4	6	1	4	17	38	10
5	8	6	80	94	1	10	1	5	.....	2	7	3	.....	9	15	24	7
Total.....	2763	506	4631	7900	.....	1454	.....	148	16	44	208	.....	287	437	724	.....	.....

\* 9 observations.

\*\* 3 observations.

\*\*\* 6 observations.

of extreme proportions because of temporarily heavy flights from nearby sources. *Anopheles quadrimaculatus* Say, on the other hand, emerges continuously and fairly uniformly all summer from all flooded fields (5), and enough flooded fields may be found in the vicinity of a trap to provide a nearly constant population.

In spite of its constant source, the anopheline shows certain cyclic variations in relative numbers collected in light traps (figs. 1 and 2). Trapping results during two seasons, when large numbers were collected, show four peak periods during one summer (1939) and three during the

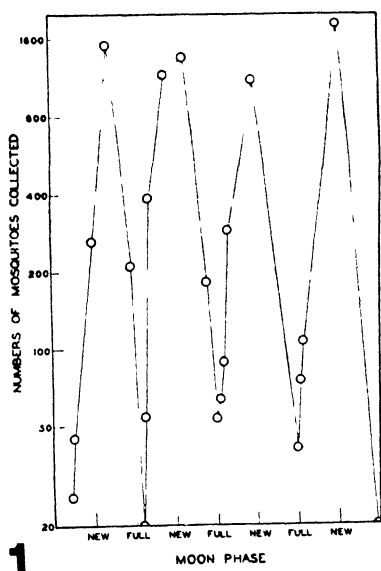


Fig. 1. Relation between lunar cycles and collections of female *Anopheles quadrimaculatus* at light at the Rice Branch Experimental Station, 1939.

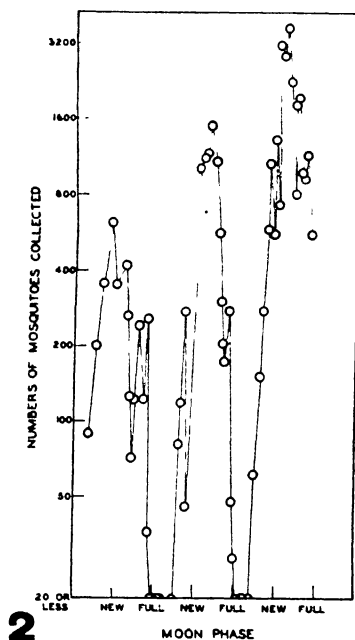


Fig. 2. Relation between lunar cycles and collections of female *Anopheles quadrimaculatus* at light at the Rice Branch Experiment Station, 1941.

other (1941). A fourth peak undoubtedly would have been indicated in 1941 had the trapping season been extended as long as in the previous season. The periods of maximum collection occurred at about monthly intervals and alternated with periods when relatively few specimens were collected (figs. 1 and 2).

The cyclic rise and fall in numbers of *Anopheles* collected in light traps coincided with the lunar cycles during the same interval. As the moon waxed, the numbers declined until hardly any were collected on or near nights when the moon was full. Conversely, as the moon waned, collections increased and reached a peak near or shortly after the appearance of the new moon.



A cyclic variation in collections of the malaria mosquito coinciding with lunar variations is indicated in the results obtained by Carpenter at Camp Robinson in 1941 (1). His graphic representation of average weekly trapping records throughout the season show four peak periods of abundance and four depressions. If the lunar phases are plotted on the graph, the peak periods of abundance coincide closely with the appearance of the new moon, and the depressions appear with the light of the moon.

Collections of the malaria mosquito made at hourly intervals during the night show that this species enters a trap in greatest numbers at different times in accordance with lunar variations (see Table I). During those nights near the time in the lunar cycle when the moon was new, three-fourths of the mosquitoes were collected between 11 and 3 o'clock. Three-fourths of the mosquitoes were collected between 12 and 3 o'clock during nights when the moon set at midnight. When the moon was full, three-fourths of the mosquitoes collected came to the trap between 9 and 2 o'clock. When the moon began the last quarter and therefore appeared after midnight, three-fourths of the mosquitoes came to the trap between 9 and 1 o'clock. The total collections made during the nights near the new moon had the greatest numbers. Next most numerous were those in the collections made during the nights when the moon entered the first quarter. Third, numerically, were the collections made at the time of the last quarter. During nights at or near full moon almost no *Anopheles* were collected.

## SUMMARY AND CONCLUSIONS

In the rice region of Arkansas, the mosquito population is composed of (1) species which vary greatly in numbers in the region of a light trap because their sources vary and (2) other species that are fairly constant numerically because their sources are not greatly variable. Under these conditions, population comparisons based on total summer collections may be inaccurate.

Malaria mosquitoes, even though their source is fairly uniform, are attracted to light traps in varying numbers as changes occur in the lunar cycle. When the moon is full or nearly so, the numbers attracted to light ebb; and when the moon is new, they are attracted in greatest numbers. The trap light is more or less effective in proportion to the intensity of the light from the moon. The darker the night, the greater the area over which the trap light exerts its attractiveness, and consequently the greater the numbers of mosquitoes attracted, other things being equal.

Malaria mosquitoes are attracted to a light trap most abundantly near and after midnight. During nights at or near the time of the new moon, this is most clearly evident. When the moon sets at midnight, most mosquitoes are attracted after midnight, and when the moon rises at midnight most mosquitoes are attracted before the moon rises. During nights when the moon is full, the attraction is not noticeably different before and after midnight.

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**MEDICAL DISEASES IN TROPICAL AND SUB-TROPICAL AREAS.** 282 pp., 108 figures. First American Edition. Size 8 $\frac{1}{4}$  x 5 $\frac{1}{4}$  inches. Published by the CHEMICAL PUBLISHING CO., INC., 234 King Street, Brooklyn, N. Y. Price \$4.75, clothbound.

This is the first time in our experience of reviewing books that a systematic search of the volume in hand fails to indicate the author or authors. The name, W. P. MacArthur, Lieutenant-General, Director General Army Medical Services, follows the preface and we assume that under his direction various authors have made a compilation. It seems further that this is the sixth edition of a British manual and it has been reprinted in the United States by permission of the Controller of His Britannic Majesty's Stationery Office.

The list of contents is: Ancylostomiasis; Arthropod Pests; Beriberi; Black-water Fever; Cerebro-Spinal Fever; Cholera; Cysticercosis; Dengue; Diarrhoea; Dysentery; Dysentery, Amoebic; Dysentery, Bacillary; Filariasis; Heat-Stroke; Hepatic Abscess; Jaundice; Leishmaniasis (Kala-Azar); Leptospirosis Ictero-haemorrhagica; Malaria; Myiasis; Oriental Sore; Paratyphoid Fever; Phlebotomus Fever; Plague; Relapsing Fever, including Tick Fever; Schistosomiasis; Scurvy; Skin Diseases; Sleeping Sickness; Small-Pox; Sprue; Trench Fever; Typhoid Fever; Typhus Fever; Undulant Fever; Yellow Fever; Appendix (Zoological Nomenclature); Index. These subjects are handled in a concise manner. Recent discoveries are included. The entomological aspects of tropical medicine are evident in the chapter titles and additional comment is unnecessary.

The appearance of this handbook of essentials now is appropriate when United States troops are entering tropical regions and accompanying physicians and sanitary officers are encountering problems which are new to them. Teachers and students, whether in medicine or entomology, should get acquainted with this subject while still at home. Our military organization is making much use of entomologists and it is the duty of these men to be informed.—C. E. VENARD.

## DESCRIPTION OF FEMALE AMPULEX (RHINOPSIS) FERRUGINEA BRADLEY

(Hymenoptera; Ampulicidae)

R. W. STRANDTMANN,  
East Texas State Teachers College,  
Commerce, Texas

*Ampulex ferruginea* was described by Bradley in 1934 (Ent. News, 45: 273, 1936) from a single male taken at Liberty, Texas. (Mar. 18, 1908, by E. G. Tucker). This is the only published record of the species and since the female has never been described it seems worth while to present the following description and collection data.

Length 9 mm. Ferruginous throughout except abdomen which is polished black. Wings infuscated apically.

*Head*.—Ferruginous, flattened dorso-ventrally, as wide as mesothorax. Eyes large, black; the posterior facets much smaller than the anterior; inner margins parallel, only very slightly concave. Ocelli three, distinct, forming a small, equilateral triangle with possibly the two upper nearer each other than to the anterior; they lie below a line drawn between the posterior margins of the compound eyes; anterior ocellus with a slight transverse impression below it. In some lights the lateral ocelli each have a slight impression on the outer side.

Frons and occiput distinctly and uniformly punctate. Cheeks and ventral surface not quite so distinctly punctate and more polished. A distinct ventral carina from base of head to that surrounding the buccal orifice. A weak tubercle on each side of head ventrally near the base.

Antennae slender, reaching a little beyond wing bases; minutely pubescent; inserted at the base of the clypeus, below the anterior margin of the eye. Scape ferruginous; pedicel and flagellum uniform color throughout, darker than the scape. A rather large, deep depression behind the insertion of the antennae. A frontal lobe overlies base of antennae, leading upward into a short carina. First joint of flagellum longer than the next two joints combined.

Clypeus, long, narrow, nose-like in appearance. Three prominent teeth on anterior margin; two less distinct ones laterally. Several pale, bristle-like setae project outward and downward from the lateral and anterior margins. Without carina or transverse median impression.

Lingual palpi four-jointed, the fourth being a long bristle. Maxillary palpi five-jointed.

Mandibles long, rather straight with the tips turning in rather sharply. Edentate. Somewhat flattened, with the inner margins thin and scythe-like. Base of the mandibles touching the eye; quite distant from the buccal orifice.

*Thorax*.—Prothorax as long as the mesothorax, little more than half as wide. Neck distinct, long. The prothorax rises abruptly from the neck, forming a raised portion narrower than the ventral part. This raised portion has a strong median sulcus which gradually disappears posteriorly; rugosely punctate dorsally on either side of the sulcus. Sides smooth and shining. A carina laterally from base of

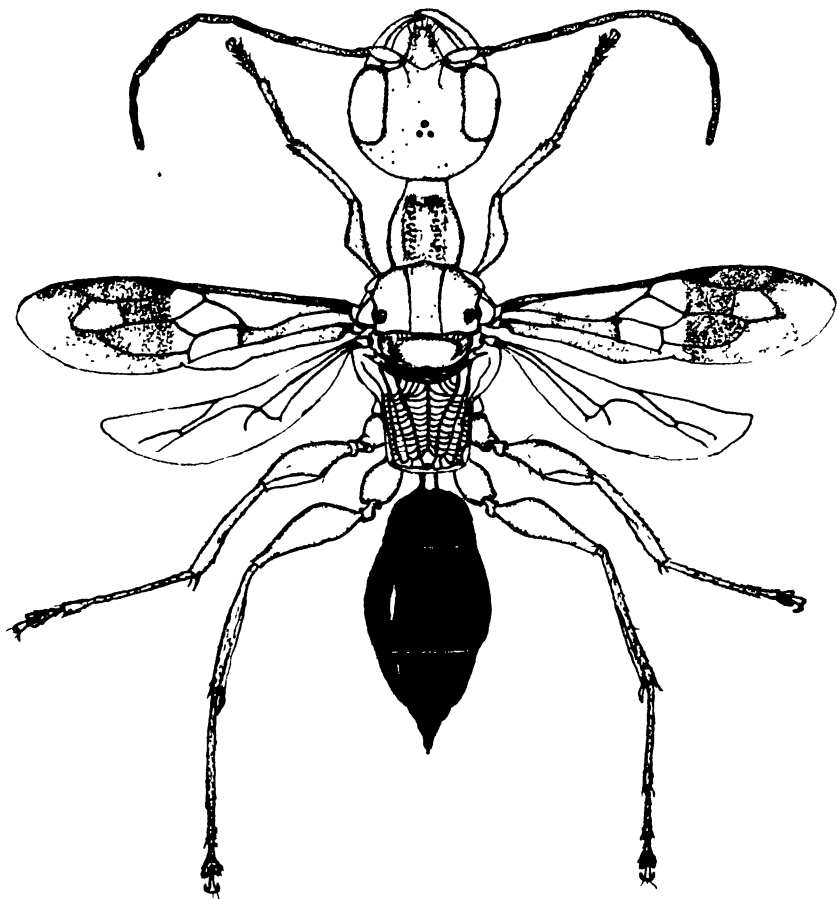


Fig. 1. Female *Ampulex ferruginea* Bradley.

head to anterior coxa and another on the mid-ventral line. Distinctly punctate ventrally. Prothoracic lobes extend laterally onto the anterior face of the mesothorax, quite distant from sclerite of fore wing. A distinct constriction between pro- and mesothorax.

Mesothorax punctate throughout. Mesonotum with parallel parapsidal furrows. A deep angular depression above wing base. The mesonotal laminae are black. A carina from below prothoracic

lobe runs obliquely backward and downward to join the longitudinal sulcus which separates the mesosternum from the pleura. The prepectal carina is distinct below the wing, disappears shortly and again becomes distinct just before it runs into the carina from the prothoracic lobe. Infuscated below, especially along the mid-ventral line. A transparent, bifurcated process projects backward from the mesosternum with one prong lying on the base of each posterior coxa.

Scutellum smooth above, deeply depressed laterally.

Postscutellum, narrow, silvery pubescent. Metapleurae smooth and shining.

Propodeum quadrangular. Nine dorsal longitudinal carinae which converge toward the apex and with numerous transverse carinae between them. A short spine on the posterior dorso-lateral angle. Sides smooth and shining anteriorly, rugose posteriorly. Posterior face slightly rounded, rugose; a silver pubescent spot above base of petiole.

*Abdomen*.—Petiole ferruginous, rest of the abdomen black, polished, shining, impunctate. Brownish tinge on the margins of all but the first segment. Ventrally the abdomen is convex with numerous pale small hairs visible in certain lights. A few pale hairs dorsally on the posterior segments.

*Legs*.—Fore legs without tarsal comb. Middle legs with two tibial spurs. Hind tibia with a line of golden pubescence on the inner face, ending in a spot of golden pubescence at the apex. All coxae large and free; hind coxae with silvery pubescence above. All femora somewhat swollen near the middle.

*Wings*.—Stigma large, dark; marginal cell appendiculate; two submarginal cells. Abruptly infuscated from a line drawn transversely through the wing from base of stigma, but gradually disappearing near the apex. Lightly infuscated from wing base to basal vein. The central part of the wing is hyaline.

Hind wing hyaline, with two closed cells.

This differs from Bradley's description of the male as follows: Clypeus has three apical teeth, only one in the male; no malar space, very short in the male; no pit behind posterior ocelli, present in the male; abdomen black, piceous in the male; thorax more punctate than male.

The above description is based on a single female taken June 11, 1939, in Hunt County, Texas, near Commerce. The insect is in the collection of the writer.

The fore legs and mandibles are not adapted for digging so it very likely stores its prey in hollow twigs as does *A. canaliculatus*.

This species can be easily distinguished from *A. canaliculatus* by the color of the head and thorax which is ferruginous in *ferruginea* and black in *canaliculatus*.

# THE AMERICAN BEES OF THE GENUS *ANTHOCOPA* WITH NOTES ON OLD WORLD SUBGENERA

(Hymenoptera, Megachilidae)

CHARLES D. MICHENER<sup>1</sup>

American Museum of Natural History,  
New York

In a recent paper on the American genera of Osmiinae<sup>2</sup> the name *Anthocopa* was used for a large number of species related to *Osmia* and *Hoplitis*. The species there included in *Anthocopa* have, for the most part, been placed in *Osmia* by previous authors. They differ from *Osmia* and resemble *Hoplitis*, however, in the linear rather than punctiform notauli. *Anthocopa* is, indeed, very closely related to *Hoplitis*. Although the two genera are easily separated in the western hemisphere, certain Eurasian groups are practically intermediate, and their placement in one genus or the other is more or less arbitrary.

Since considerable space has been devoted to outlining the generic characters in the paper already referred to, it will suffice to state here that *Anthocopa* may be distinguished from *Hoplitis* by the robust, *Osmia*-like form, with the anterior face of the first tergite longer than the dorsal face and separated from it by a line or carina, and commonly by the presence of a carina along the inner ventral angle of each posterior coxa. American species of *Anthocopa* agree in certain characters used to distinguish various Old World subgenera. Thus females of all our species have the clypeus produced well over the base of the labrum. Antennae of the males in our species are simple, and except in *A. xerophila* they are as short (or nearly as short) as those of the females.

A brief historical review of the American species of the genus is of interest because it gives an indication of the richness of the western bee fauna, which has only recently received any considerable study. Our first species of this genus was described in 1878 by Cresson, and the next by Cockerell in 1908. A third was described by Cockerell in 1930, fourteen more by the same author in 1935, two by Michener in 1936, and eight additional species and one subspecies are made known in the present paper.

## DISTRIBUTION AND PHYLOGENY

All known American *Anthocopa* are found in the western United States, the easternmost records being at the eastern foot of the Rocky

<sup>1</sup>I wish to thank Mr. G. E. Bohart, Dr. R. M. Bohart, Mr. U. N. Lanham, Dr. E. G. Linsley, Mr. J. W. MacSwain, Dr. E. S. Ross, Dr. H. A. Scullen, the late Mr. E. P. Van Duzee, and especially Mr. P. H. Timberlake for the opportunity to study specimens from their own collections or from the collections of which they are in charge. Furthermore, for numerous courtesies and much helpful advice, I express my gratitude to Dr. Linsley and Prof. E. O. Essig.

This paper was prepared at the University of California, Berkeley, California.

<sup>2</sup>Michener, C. D., 1941, A generic revision of the American *Osmiinae* with descriptive notes on Old World genera. Amer. Midl. Nat., 26: 147-167, 21 figs.

Mountains. The subgenera *Atoposmia* and *Hexosmia* are montane and northern groups rather common in the high mountains of California, and occurring on the high ranges of the Great Basin and in the Rocky Mountains of Colorado. The center of abundance, both of individuals and of species, for both of these subgenera is in California, and for *Atoposmia* it appears rather clearly to be on the high, arid slopes of the mountain ranges facing the Great Basin. *Atoposmia* is rather clearly related to the Eurasian subgenera *Anthocopa* s. str. and *Glossosmia*.

The other American subgenera, *Eremosmia*, *Xerosmia* and *Phaeosmia*, are groups largely confined to the desert immediately east of the mountains which separate the Great Basin and Colorado Desert areas from the moister coastal regions. That is, they occur in the western part of the Great Basin and Colorado Desert regions. They have not yet been found outside of California. Indeed most of the specimens of these subgenera which have thus far been collected come from points within easy view of the mountains which form the western boundaries of the desert areas.

It is interesting to note that the area in which these desert subgenera occur is precisely the region in which the species of *Ashmeadiella* are most abundant and diversified. It seems likely, as suggested in the paper on *Ashmeadiella*<sup>3</sup>, that these groups [there mentioned as derivatives of *Osmia*, (a generic name there used in a broad sense)] originated in a manner comparable to *Ashmeadiella*, but probably at a considerably later time, as shown by their limited distribution and diversification. In all probability, montane types, upon coming in contact with adjacent desert areas, gave rise to the desert subgenera. To judge from the close relationship to *Hoplitis* shown by some Palearctic forms, and the large number and great diversity of species of that region, Eurasia is the area in which *Anthocopa* (as well as *Hoplitis*) originated.

At least two distinct types of *Anthocopa* have entered the Nearctic region from the Palearctic. One of these apparently gave rise to *Atoposmia* and *Eremosmia*, the other to *Hexosmia* and *Phaeosmia*, probably to *Xerosmia* and perhaps to the genus *Ashmeadiella*.

### HABITS

Very little is known of the nesting habits of American species of *Anthocopa*. Numerous specimens of *A. xerophila* were reared (by Mr. J. W. MacSwain) from old nests of *Anthophora linsleyi* Timberlake (collected by Mr. G. E. Bohart).

The flower visiting habits, however, are comparatively well known and are clearly correlated with the structural characters upon which the subgenera are based. Thus *Xerosmia* apparently collects pollen only from *Cryptantha*, *Phaeosmia* from the Compositae, *Hexosmia* from from Hydrophyllaceae such as *Phacelia* and *Nemophila*, and *Eremosmia* from both Leguminosae and Hydrophyllaceae. The pollen collecting activities of *Atoposmia* are almost entirely limited to *Pentstemon*.

The subsequent part of this paper is divided into two sections, the first dealing with American subgenera and species, and the second dealing with Old World subgenera.

<sup>3</sup>Michener, C. D., 1939, A revision of the genus *Ashmeadiella*, Amer. Midland Nat., 22: 1-84.

## PART I

## AMERICAN SUBGENERA AND SPECIES OF ANTHOCOPA

## KEY TO THE AMERICAN SUBGENERA OF ANTHOCOPA

## MALES

1. Mandibles tridentate. .... 2  
Mandibles bidentate. .... 3
2. Trophi long, when folded reaching well behind anterior coxae; posterior coxae with carina along inner ventral angle feeble (p. 51) ..... **Atoposmia**  
Trophs short, when folded hardly reaching fore coxae; posterior coxae each with a conspicuous carina along inner, ventral angle (p. 66) ..... **Eremosmia**
3. Maxillary galeae and labial palpi furnished with stiff hairs with hooked apices; seventh tergum largely exposed, with a large transverse sulcus medially and three long teeth apically (p. 81) ..... **Xerosmia**  
Maxillary galeae and labial palpi without hooked hairs; seventh tergum but little if at all exposed, not tridentate. .... 4
4. Posterior coxae each with strong longitudinal carina on inner ventral angle; clypeal truncation much longer than distance from its end to lateral angle of clypeus; black, without metallic luster (p. 77) ..... **Phaeosmia**  
Posterior coxae with inner ventral carinae feeble; clypeal truncation concave and shorter than distance from its end to lateral angle of clypeus; body with feeble metallic luster (p. 74) ..... **Hexosmia**

## FEMALES

1. Maxillary galeae and first two segments of labial palpi furnished with stiff hairs with hooked apices (p. 81) ..... **Xerosmia**  
Maxillary galeae and labial palpi without hooked hairs. .... 2  
(See *A. palmarum* (Cockerell), the trophi of the type of which have not been examined.)
2. Trophi long, when folded reaching well behind anterior coxae; posterior coxae with carina along inner ventral angle feeble (p. 51) ..... **Atoposmia**  
Trophs short, when folded hardly reaching anterior coxae; posterior coxae with carinae along inner ventral angles variable in strength. .... 3
3. Body with a feeble metallic green luster; posterior coxae with inner ventral carinae weak (p. 74) ..... **Hexosmia**  
Body black, without metallic luster; posterior coxae each with a strong carina on inner ventral angle. .... 4
4. Mandibles more than four times as long as shortest breadth (length measured from apex to lower basal angle) (p. 66) ..... **Eremosmia**  
Mandibles less than four times as long as greatest breadth (p. 77) ... **Phaeosmia**

Subgenus **Atoposmia** Cockerell

*Atoposmia* COCKERELL, 1935, Pan-Pac. Ent. 11: 50. MICHENER, 1936, Can. Ent., 68: 41.

Type species: *Osmia triodonta*, Cockerell, by original designation.

Black without metallic tints. Eyes with inner margins subparallel in male, slightly converging below in female; mandibles of male tridentate, of female tridentate or with inner subapical angle produced distally to form a fourth tooth; mandibles of female sometimes slender, over four times as long (measured from lower basal angle to apex) as shortest breadth, in other species much more robust, less than three times as long as shortest breadth; trophi much elongated, first segment of labial palpi less than one-fourth as long as second. Longitudinal carina of inner ventral angle of each posterior coxa weak or nearly absent. Second sternum of male considerably



enlarged, its posterior margin broadly rounded, third sternum usually emarginate posteriorly, the emargination fringed; sixth tergum toothed or angulate laterally, seventh exposed apically and normally with a pair of apical lobes between which stands a tooth (either the lobes or the tooth may be reduced).

This is primarily a montane subgenus of the western United States, confined almost entirely in its flower visiting habits to species of *Pentstemon*.

## KEY TO THE SPECIES OF ATOPOSMIA

### FEMALES

1. Mandibles quadridentate as a result of the distad production of the subapical dorsal swelling; apex of clypeus with a small, deep, median emargination between a pair of submedian teeth (p. 65)..... **panamintensis**
2. Mandibles tridentate; apex of clypeus simple or slightly sinuate..... 2
2. Maxillary palpi shorter than first segment of labial palpi, apparently four-segmented; mandibles about three times as long as shortest width (p. 64),  
Maxillary palpi about equal in length to first segment of labial palpi, five-segmented; mandibles at least slightly more than three times as long as shortest width..... 3
3. Cheeks finely and densely punctate, more finely so above than middle of vertex, and furnished with numerous rather short, depressed, anteriorly directed hairs (which are inconspicuous if dark in color); clypeus closely punctate, punctures about as fine as those of frons..... 4
- Cheeks as coarsely or more coarsely punctate than vertex, punctures not dense, pubescence sparse and less depressed than in above; clypeus usually more coarsely and less closely punctate than frons..... 5
4. Scopa yellowish white (p. 62)..... **triodonta**
- Scopa ferruginous, sometimes blackish laterally and posteriorly (p. 64),  
**shastensis**
5. Scopa black or reddish black; abdominal terga with much black pubescence... 6
- Scopa and abdominal pubescence white..... 7
6. Disc of mesoscutum with punctures widely separated and smaller than those of rest of scutum or of vertex (p. 57)..... **abjecta**
- Disc of mesoscutum with punctures less widely separated, larger than those of rest of scutum or of most parts of vertex (p. 54)..... **nigrior**
7. Abdominal scopa short, that of second sternum little if at all longer than greatest length of exposed portion of second tergum (p. 53)..... **oregona**
- Abdominal scopa long, especially anteriorly, that of second sternum markedly longer than greatest length of second tergum..... 8
8. Notch between first and second mandibular teeth prolonged into a deep narrow sinus (as in fig. 1); subapical dorsal swelling of mandible distant from apex of third tooth by distance equal to or scarcely less than shortest width of mandible (p. 60)..... **anthodyta**
- Notch between first and second mandibular teeth simple, acute but not prolonged into a narrow sinus; subapical dorsal swelling distant from third tooth by distance equal to little if any over one-half shortest width of mandible..... 9
9. Inner hind tibial spur practically straight (p. 61)..... **elongata**
- Inner hind tibial spur bent apically (p. 57)..... **alta**

### MALES

1. Posterior margin of third abdominal sternum with a but feebly emarginate, fringed median section (p. 65)..... **panamintensis**
- Posterior margin of third abdominal sternum with a more or less strong emargination, if shallow, made conspicuous by the fringe which is long laterally so that the apical margin of the fringe is strongly emarginate..... 2
2. Maxillary palpi apparently four-segmented, much shorter than first segment of labial palpi; lateral margins of sixth tergum convex (p. 64)... **pyncognatha**

- Maxillary palpi five-segmented, fully as long as first segment of labial palpi; lateral margins of sixth tergum usually but feebly convex or slightly sinuate.....3
3. Truncation of clypeus slightly produced, but little longer than distance from end of truncation to lateral angle of clypeus (p. 61).....*elongata*
- Truncation of clypeus not produced, usually over three times as long as distance from end of truncation to lateral angle of clypeus.....4
4. Seventh tergum with lateral lobes exceeding median tooth.....5
- Seventh tergum with median tooth exceeding lateral lobes.....8
5. Second tergum with punctures of median portion of dorsum minute and separated by many times their diameters.....6
- Second tergum with punctures of median portion of dorsum larger and separated at most by four or five times their diameters (p. 62).....*tridentata*
6. Impunctate margin of clypeal truncation rather broad.....7
- Impunctate margin of clypeal truncation exceedingly narrow (p. 64),  
*shastensis*
7. Distance between posterior ocelli less than distance from one of them to eye margin (p. 57).....*alta*
- Distance between posterior ocelli equal to distance from one of them to eye margin (p. 59).....*mesae*
8. Lateral margins of sixth tergum strongly convex; abdomen with fuscous and blackish hairs, especially laterally (p. 54).....*nigrior*
- Lateral margins of sixth tergum straight or nearly so; abdominal pubescence pale.....9
9. Mandibles with inner apical angle right angular (p. 53).....*oregona*
- Mandibles with inner apical angle acute (appearing right angular in certain views) (p. 60).....*anthodyta*

***Anthocopa (Atoposmia) oregona*, n. sp.**

(Fig. 23)

This is a moderate sized, rather slender species. It resembles *panamintensis* in having a short, white scopa in the female, but differs from that species in the tridentate mandibles. This species resembles *nigrior* except for the black pubescence, but differs from that species in the straight lateral margins of the sixth tergum of the male, the more acute second mandibular tooth of the female, etc.

*Female*.—Length  $8\frac{1}{2}$  mm. (varying to 7 mm. among paratypes). Pubescence dull white. Punctures of head rather coarse, dense on the frons but elsewhere conspicuously separated, those of clypeus larger than those of frons or vertex; anterior ocellus farther from antennal bases than from posterior edge of vertex; distance between posterior ocelli equal to distance to eye margin, greater than distance to posterior edge of vertex; pubescence of cheeks sparse, suberect; clypeus with a longitudinal median raised, impunctate line (rarely inconspicuous), truncation slightly emarginate medially, broadly rounded at ends; mandibles nearly four times as long as shortest breadth, tridentate, notch between first and second teeth not deepened into a sinus, third tooth with inner margin parallel to long axis of mandible so that the tooth is strongly acute, subapical inner swelling distad from third tooth (from paratype) by distance equal to about two-thirds of shortest width of mandible; maxillary palpi (from paratype) five-segmented, about as long as first segment of labial palpi, third segment much the longest. Thorax with punctures for the most part about as large as largest on vertex, and in most areas separated by about half their diameters or less, but those of

center of disc of mesoscutum and of mesepisternum separated by their diameters or more, and with a few minute punctures among them; enclosure of propodeum hardly roughened above medially; inner hind tibial spurs slightly curved apically. Abdomen rather finely punctate, punctures of median part of second tergum separated by more than their diameters; scopa white, longest hairs of second sternum shorter than length of exposed portion of second tergum; apical pubescent bands of terga feeble and broadly broken medially.

*Male*.—Length  $7\frac{1}{2}$  mm. Similar to female in appearance and punctuation; punctures of clypeus a little finer than in female, but not fine and close as in many males; truncation of clypeus over three times as long as distance from its end to lateral angle of clypeus, margin of truncation coarsely and rather irregularly crenulate, rather broadly impunctate. Third abdominal sternum with a conspicuous fringed emargination; sixth tergum with a tooth ending in a right angle (sometimes reduced to a feeble bend in the margin) at each side; lateral margins of sixth tergum somewhat sinuate, convex toward the rear; seventh tergum with median apical tooth, but lateral lobes reduced to rounded shoulders (in some lateral lobes better developed, but shorter than median tooth).

*Holotype* female (Calif. Acad. Sci. Ent. No. 5168), allotype male (Calif. Acad. Sci., Ent. No. 5169), and four paratypes: McKenzie Pass, Oregon, 5000 feet elevation, July 18, 1927 (H. A. Scullen); one female paratype, Cloud Cap, Crater Lake, Oregon, 7500 feet elevation, August 2, 1930, on *Pentstemon* (H. A. Scullen); three female paratypes, Mt. Hilman, Crater Lake, 7500 to 8000 feet elevation, July 31, 1930 (H. A. Scullen).

I am indebted to Dr. H. A. Scullen for the opportunity to study this species, as well as for permission to place the types in the collection of the California Academy of Sciences. Paratypes will be found in the Oregon State College collection, and in that of the author.

### ***Anthocopa (Atoposmia) nigrior*, n. sp.**

(Fig. 28)

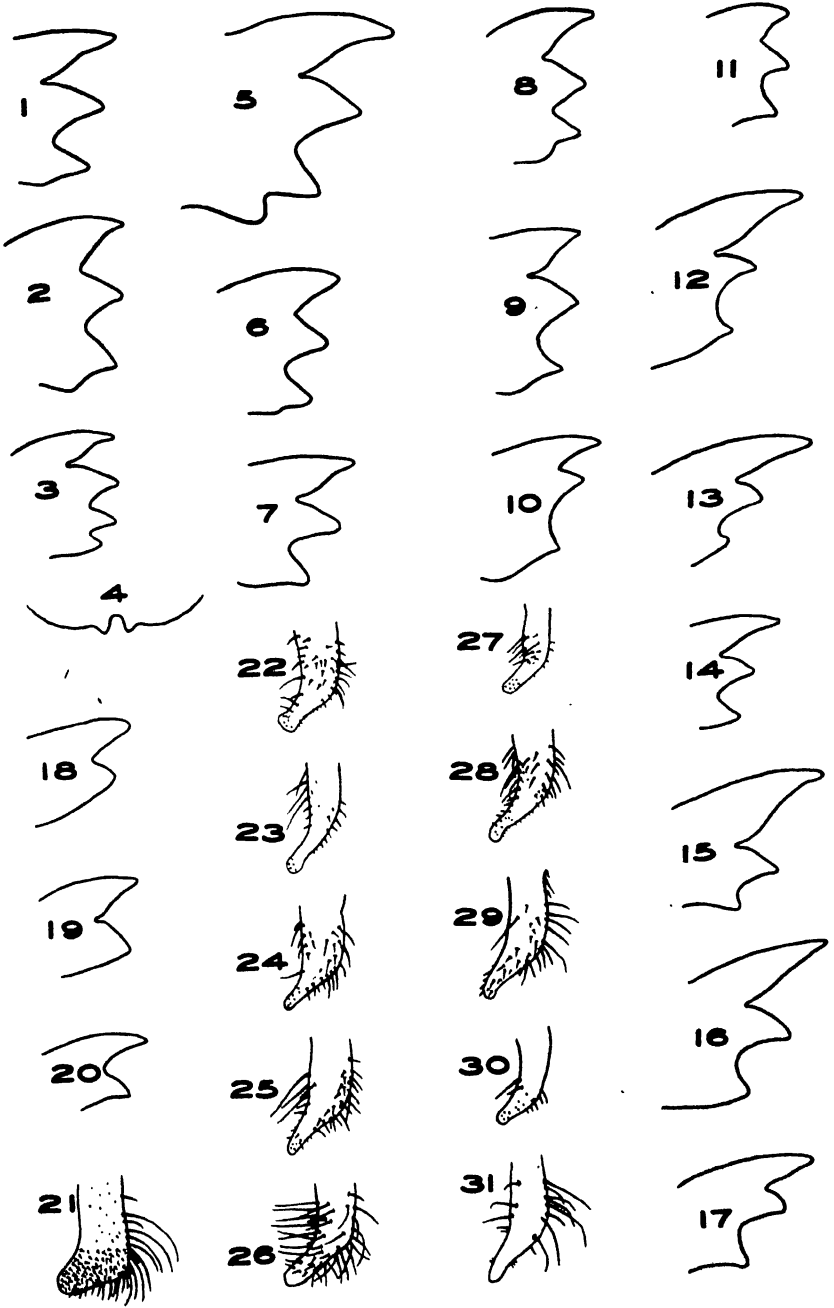
This is a moderate sized, rather slender species distinguished from others except *abjecta* by the partly fuscous and black pubescence and black scopa of the female and fuscous and blackish pubescence on the abdomen of the male. The scopa of the female is longer than in *oregona*, shorter than in species such as *alta*. It differs from *abjecta* by the coarsely

### EXPLANATION OF PLATE

Apices of mandibles of: 1, *Anthocopa anthodyta*, ♀; 2, *A. triodonta triodonta*, ♀; 3, *A. panamintensis*, ♀; 4, margin of clypeus of *A. panamintensis*, ♀.

Apices of mandibles of: 5, *A. robustula*, ♀; 6, *A. nitidivitta*, ♀; 7, *A. rupestris*, ♀; 8, *A. mortua*, ♀; 9, *A. enceliae*, ♀; 10, *A. laevibullata*, ♀; 11, *A. copelandica*, ♀; 12, *A. triodonta triodonta*, ♂; 13, *A. anthodyta*, ♂; 14, *A. panamintensis*, ♂; 15, *A. robustula*, ♂; 16, *A. nitidivitta*, ♂; 17, *A. rupestris*, ♂; 18, *A. mortua*, ♂; 19, *A. enceliae*, ♂; 20, *A. copelandica*, ♂.

Apices of male gonopods of: 21, *A. xerophila*; 22, *A. anthodyta*; 23, *A. oregona*; 24, *A. panamintensis*; 25, *A. triodonta triodonta*; 26, *A. nitidivitta*; 27, *A. elongata*; 28, *A. nigrior*; 29, *A. pycnogatha*; 30, *A. robustula*; 31, *A. rupestris*.



punctate disc of the mesoscutum, coarser punctures of the head, slightly different mandibular structure, etc.

*Female*.—Length 8 mm. (to 10 mm. in paratypes). Pubescence of head grayish white with black hairs intermixed on frons and vertex, that of clypeus almost entirely black; punctures of head not very dense, but separated for the most part by much less than half their diameters, those of clypeus dense, slightly coarser than those of frons and vertex and arranged in longitudinal rows; anterior ocellus farther from antennal bases than from posterior edge of vertex; distance between posterior ocelli equal to distance from one of them to eye margin, greater than distance to posterior edge of vertex; pubescence of cheeks sparse, suberect; clypeal truncation rounded at ends, somewhat emarginate medially, but little shorter than distance from end to lateral angle of clypeus; mandibles but little more than three times as long (measured from ventral, basal angle) as shortest width, tridentate, notch between first and second teeth not deepened as a narrow sinus, subapical inner swelling distant from apex of third tooth by distance equal to over half of shortest width of mandible. Thorax with pubescence grayish white; punctuation of mesoscutum similar to more coarsely punctured portions of vertex, punctures of discal area more widely separated; punctures of mesepisterna coarser, separated by much less than their diameters; enclosure of propodeum broadly roughened above; pubescence of legs black or dusky, inner hind tibial spurs curved apically. Abdomen rather strongly punctured, punctures of middle of second tergum separated, for the most part, by two or three times their diameters; scopa black; pubescence of abdominal terga black or dusky, except for white hairs at the posterior margins laterally.

*Male*.—Length 9 mm.; similar to female in appearance. Pubescence white, that of abdomen intermixed especially laterally with fuscous and black. Punctuation of clypeus finer and closer than that of rest of head; distance between posterior ocelli greater than distance to posterior edge of vertex which is greater than distance to eye margin; clypeal truncation more than three times as long as distance from its end to lateral angle of clypeus, margin of truncation feebly crenulate and narrowly impunctate; maxillary palpi five-segmented, as long as first segment of labial palpi, third segment much the longest, second next longest. Third abdominal sternum with a broad fringed emargination in posterior margin; sixth tergum with a tooth at each side ending in a somewhat obtuse angle, lateral margins of sixth tergum convex; seventh tergum with a broad median tooth with a rounded apex, lateral lobes reduced to rounded shoulders.

*Holotype* female (Calif. Acad. Sci., Ent. No. 5170): Onion Creek Meadows, Grant County, Oregon, 7700 feet elevation, July 18, 1936 (R. E. Rieder). Allotype male: (Calif. Acad. Sci., Ent. No. 5171): Hermiston, Oregon, May 10, 1930 (H. A. Scullen). Two female paratypes: Wallowa, Wallowa County, Oregon, June 27, 1936, on thistle (I. McCracken).

As in the case of the preceding species, permission to place the types in the collection of the California Academy of Sciences was kindly granted by Dr. H. A. Scullen.

***Anthocopa (Atoposmia) abjecta* (Cresson)**

*Osmia abjecta* CRESSON, 1878, Trans. Am. Ent. Soc., 7: 103; COCKERELL, 1906, Bull. Am. Mus. Nat. Hist., 22: 446; FRIESE, 1911, Das Tierreich, 28: 144; COCKERELL, 1928, Univ. Colorado Studies, 16: 124, 125; COCKERELL, 1932, Bull. Brooklyn Ent. Soc., 27: 204; MICHENER, 1936, Can. Ent. 68: 41.  
*Hoplitis abjecta* SANDHOUSE, 1939, Mem. Ent. Soc. Washington, 1: 139.

This is a moderate sized robust species, similar to *A. nigrior* in the black or reddish black scopa, and black pubescence of the clypeus, legs, and terga. It differs from *nigrior* in the more robust form, finer, sparser punctation, etc.

*Female*.—Length 7 mm. Pubescence of head grayish white, that of clypeus fuscous and black; punctures of head not dense, in many areas separated by half their diameters, those of clypeus as coarse as coarsest punctures of vertex, dense and arranged in rows only in apical half of clypeus; anterior ocellus farther from antennal bases than from posterior edge of vertex, distance between posterior ocelli equal to distance to eye margin, greater than distance to posterior edge of vertex; pubescence of cheeks sparse, suberect; clypeal truncation rounded at the ends, feebly emarginate medially, slightly shorter than distance from its end to lateral angle of clypeus; mandibles tridentate, a little more than three times as long as shortest breadth, notch between first two teeth not deepened as a narrow sinus, subapical inner swelling distant from apex of third tooth by distance equal to less than half shortest breadth of mandible; apex of second tooth nearer to apex of first than to apex of third (in contrast to other species). Thorax with pubescence grayish white, that of sternum fuscous, punctation of mesoscutum rather fine, disc shining with punctures reduced in size and separated by several times their diameters; mesepisternum more coarsely punctured than mesoscutum, punctures separated by some shining ground in which are a few minute punctures; enclosure of propodeum somewhat roughened above; pubescence of legs black, inner hind tibial spurs curved apically. Abdomen finely and sparsely punctate, punctures of middle of second terga minute and separated by a number of times their diameter; scopa black or reddish black, elongate anteriorly so that longest hairs of second sternum are conspicuously longer than length of second tergum; pubescence of abdominal terga black except for white hairs at posterior margins of first three terga.

*Type*: from Colorado, in Academy of Natural Sciences of Philadelphia. Although widely distributed in Colorado, the male of this species has never been recognized. It is to be expected that it will be similar to that of its closest relative, *A. alta*. The above description is based on a specimen from Longs Peak Inn, Colorado, 8000 feet, June 30, 1928 (E. C. Van Dyke).

***Anthocopa (Atoposmia) alta* (Michener)**

*Osmia alta* MICHENER, 1936, Can. Ent., 68: 41, ♀.  
*Hoplitis alta* SANDHOUSE, 1934, Mem. Ent. Soc. Washington, 1: 139.

This is a moderate sized, rather robust species, differing from *A. anthodyta* which it closely resembles in general appearance by the thicker

mandibles of the female and the large lateral lobes and reduced median tooth of the sixth tergum of the male. It differs from *A. abjecta*, to which it is very closely related, by the pale pubescence, the yellowish or brownish scopa, and the position of the ocelli with relation to the posterior edge of the vertex and the compound eyes.

*Female*.—Length  $6\frac{1}{2}$ –7 mm. Pubescence grayish white with a few fuscous hairs intermixed on dorsum of thorax and occupying regions between fasciae on abdominal tergites; pubescence of anterior margin of clypeus yellowish. Punctures of head coarse and rather close, largely separated by one-fourth their diameters or less, those of cheeks and vertex often by half their diameters, those of clypeus about same size as larger punctures of frons and vertex and sometimes conspicuously separated on basal half; anterior ocellus much posterior to midpoint between antennal bases and posterior edge of vertex, distance between posterior ocelli equal to or slightly greater than distance to posterior edge of vertex but less than distance to eye margin; pubescence of cheeks sparse, suberect; clypeal truncation rounded at ends, feebly crenulate, slightly shorter than distance from end of truncation to lateral angle of clypeus; mandibles three-toothed, but little more than three times as long as shortest breadth, outer apical tooth rather short, notch between first and second teeth not or but little deepened into a sinus; distance from apex of first to apex of second tooth equal to or slightly less than distance from second to third; subapical inner swelling distant from apex of third tooth by distance equal to half or slightly over half shortest width of mandible; maxillary palpi longer than first segment of labial palpi, five-segmented, third segment longest. Thorax with punctures of mesoscutum similar to those of frons but more widely separated, disc commonly with punctures reduced in size and separated by several puncture widths; mesepisternum more coarsely and less closely punctured than mesoscutum; upper part of propodeal enclosure strongly roughened except medially; inner hind tibial spurs somewhat bent at apices. Abdomen finely and sparsely punctate, punctures of middle of second tergum minute and separated a number of times their diameters; scopa typically yellow-brown in some lights, sometimes yellow without brown tints, elongate anteriorly, longest hairs of second sternum being considerably longer than length of second tergum; apical pubescent bands of abdominal tergites broken medially on first three terga.

*Male*.—Length 7–8 mm. Similar to female in appearance and punctuation; clypeus more finely and densely punctured than most of frons or vertex; distance between posterior ocelli less than distance to posterior edge of vertex which is less than distance to eye margin; clypeal truncation somewhat crenulate medially, nearly or about four times as long as distance from end to lateral angle of clypeus, impunctate margin of truncation rather broad. Posterior margin of third abdominal sternum with an evident emargination, fringed with long hairs; sixth tergum with a tooth ending in a right or obtuse angle at each side, lateral margins of sixth tergum nearly straight; seventh tergum with lateral lobes rather narrowly rounded and conspicuously exceeding median tooth which is reduced to a mere swelling of the margin.

*Type:* female; Garnet Lake, California, on loan deposit to the California Academy of Sciences. One female, Lone Pine Canyon, Inyo County, California, 8500 feet, June 11, 1937 (C. D. Michener); one female and two males, Gold Lake, Sierra County, California, July 31, 1921 (C. L. Fox); one male and one female, Science Lodge, west Boulder County, Colorado, July 6, 1939 (U. L. Lanham).

Considerable variation is shown in the small series of this species before me. The female from Science Lodge is very small. Both this specimen and the female from Gold Lake have the mesoscutum more closely punctured than in typical specimens lacking the area of small, widely separated punctures in the center, and the scopa in these individuals shows little or no brown. Males from both these localities, however, have the area of widely separated punctures in the center of the disc of the scutum. In the Gold Lake female, the head is less closely punctate than in the rest, the punctures of the upper part of the clypeus being well separated. While I believe all these to be individual variations, it is possible that they indicate the presence of two or more distinct species. It is also possible that the species will eventually fall as a form of *abjecta*, to which it is closely related, but the Colorado female of *alta* has a very pale scopa, and in no way suggests intergradation with that species.

#### ***Anthocopa (Atoposmia) mesae* (Cockerell)**

*Hoplitis mesae* COCKERELL, 1930, Am. Mus. Nov., 397: 2.

*A. mesae* is the only species of *Atoposmia* not known from the female. It is probable, indeed, that it is the male of *abjecta*, a species known only from the female. This hypothesis is strengthened by the similarity of *mesae* to the male of *alta*, the female of which is very similar to *abjecta*. However, since no female *Atoposmia* are known from southwestern Colorado, from which area *mesae* was described, it seems best not to place *mesae* in the synonymy of *abjecta* until further evidence can be obtained.

*Male*.—Length 8.5 mm. (abdomen straightened). Pubescence whitish, badly worn in type. Punctures of clypeus and supraclypeal area fine and dense, becoming progressively larger and more widely separated on frons, vertex, and cheeks; clypeus with anterior margin moderately widely impunctate, apex not much produced, truncation slightly sinuate and more than four times as long as distance from end of truncation to lateral angle of clypeus; anterior ocellus behind midpoint between antennal bases and posterior edge of vertex; distance between posterior ocelli about equal to distance from one of them to eye margin or to posterior margin of vertex; maxillary palpi five-segmented, third segment longest. Thorax with punctures of mesoscutum mostly similar in size to those of frons but separated by two to four puncture widths medially; mesepisternum closely punctured and much more coarsely so than mesoscutum; upper part of propodeal enclosure strongly roughened; inner hind tibial spurs slightly curved apically. Abdomen finely punctate, punctures of middle of second tergum minute and separated by several times their diameters; posterior margin of third sternum with a distinct broad



emargination; sixth tergum with obtuse tooth at each side; seventh tergum with lateral lobes much exceeding median tooth which is reduced to a mere convexity of the margin.

*Type*: male; Mesa Verde, Colorado, in the collection of The American Museum of Natural History. This species is known only from the unique type.

***Anthocopa (Atoposmia) anthodyta*, n. sp.**

(Figs. 1, 13, and 22)

This is a moderate sized, robust species which may be distinguished from all others by the greatly narrowed median portion of the mandibles of the female. The male is similar to that of *oregona*, the lateral lobes of the seventh tergum being much reduced, but differs from that species by the slightly acute third mandibular tooth, the absence of an impunctate, longitudinal, median, raised line on the clypeus, etc.

*Female*.—Length  $7\frac{1}{2}$  mm. (varying from 7 to 8 mm.). Pubescence whitish. Punctures of head dense (not so fine as in other densely punctate species, as *triadonta* and *pyncognatha*), those of clypeus somewhat elongate and slightly larger than those of rest of head; anterior ocellus much farther from antennal bases than from posterior edge of vertex; distance between posterior ocelli equal to (sometimes slightly greater than) distance to posterior edge of vertex, which is less than distance to eye margin; pubescence of cheeks sparse, suberect; clypeal truncation broadly rounded at ends, hardly emarginate medially, shorter than distance from its end to lateral angle of clypeus; mandibles tridentate, much narrowed basad to middle so that they are more than four times as long as shortest width, outer tooth long and slender, notch between it and second tooth prolonged as a narrow sinus, subapical inner swelling basad from apex of third tooth by distance nearly equal to shortest width of mandible; maxillary palpi five-segmented, fully as long as first segment of labial palpi, third segment longest. Thorax with mesoscutum conspicuously more coarsely punctured than vertex, punctures close around the margins, separated by less than their diameters even in center of disc; mesepisternum with punctures slightly coarser than those of scutum and more widely separated, especially below, where there are minute punctures interspersed among the larger ones; enclosure of propodeum slightly roughened above medially, more strongly so laterally; inner hind tibial spurs nearly straight. Abdomen with punctures of center of second tergum separated by two or three times their diameters; scopa yellowish white, elongate anteriorly, hairs of second sternum being longer than length of second tergum; apical pubescent bands of abdominal terga broken medially.

*Male*.—Length  $8\frac{1}{2}$  mm. (varying to 7 mm.). Similar to female in appearance and punctation; punctures of clypeus about the size of smaller punctures of vertex; punctures of vertex more widely separated in some areas than in the female; distance between posterior ocelli less than (or equal to) distance to posterior edge of vertex, which is less than (or equal to) distance to eye margin; truncation of

clypeus nearly four times as long as distance from end of truncation to lateral angle of clypeus, crenulate, impunctate margin rather broad; mandibles with inner apical tooth acute, at least in some views. Third abdominal sternum with a broad emargination, fringed with long hairs; lateral teeth of sixth tergum slightly obtuse (varying to somewhat acute), lateral margins of sixth tergum relatively straight (sometimes sinuate or convex next to tooth); seventh tergum with lateral lobes reduced to mere shoulders, much exceeded by the median tooth.

*Holotype* female (Calif. Acad. Sci., Ent. No. 5156), allotype male (Calif. Acad. Sci., Ent. No. 5157), and ten paratypes: Lone Pine Canyon, Inyo County, California, 8500 feet elevation, June 11, 1937 (C. D. Michener). Two paratypes no doubt from same locality but labeled Mt. Whitney, Inyo County, California, June 12, 1937 (collector unknown, Bohart collection). Numerous additional specimens are from Mill Creek, San Bernardino Mountains, California, 6000 feet, on *Penstemon grinnelli* June 20, 1937, June 26, 1938, and August 30, 1940 (P. H. Timberlake).

### ***Anthocopa (Atoposmia) elongata* (Michener)**

(Fig. 27)

*Osmia elongata* MICHENER, 1936, Can. Ent., 68: 41.

*Hoplitis elongata* SANDHOUSE, 1939, Mem. Ent. Soc. Washington, 1: 139.

This is the smallest species in the subgenus, and is quite slender.

*Female*.—Length 6 to nearly 7 mm. Pubescence white or nearly so. Punctures of head not dense, except immediately behind the ocelli for the most part separated by about half their diameters, those of clypeus coarser than those elsewhere; anterior ocellus much nearer to posterior edge of vertex than to antennal bases; distance between posterior ocelli equal to or slightly less than distance to eye margin, which distance is markedly greater than distance to posterior edge of vertex; pubescence of cheeks sparse, suberect; clypeal truncation much produced, broadly rounded at the ends, slightly emarginate medially; mandibles tridentate, little over three times as long as shortest breadth, outer tooth short and robust for *Atoposmia*, notch between first and second mandibular teeth not prolonged into a narrow sinus, distance between subapical inner swelling and apical tooth a little over half shortest breadth of mandible; maxillary palpi as long as first segment of labial palpi, five-segmented, third segment longest. Thorax strongly punctate, mesoscutum with punctures separated by much less than half their diameters and as large as largest punctures of vertex, no discal area of more widely separated punctures; mesepisterna, especially below, with punctures larger and more widely separated than those of scutum and with a few minute punctures interspersed among them; enclosure of propodeum but little roughened above medially; inner hind tibial spur straight. Abdomen finely and sparsely punctate middorsally, punctures of middle of second tergum separated by several times their diameters; scopa yellowish white, much elongated anteriorly, hairs of second sternum almost twice as

long as second tergum; apical pubescent bands of anterior abdominal terga broken medially.

*Male*.—Length 6 mm. Similar to female in appearance and punctation; clypeus little if any more coarsely punctate than certain areas of frons and vertex; distance between posterior ocelli equal to distance to posterior edge of vertex, which is less than distance to eye margin; clypeal truncation slightly produced so that normal lateral apical angles of clypeus are on lateral apical margins and the slightly crenulate truncation, which has an impunctate margin of moderate width and distinct (not rounded) angles at the ends, is only one and one-half times as long as distance from end of truncation to lateral angle of clypeus. Third abdominal sternum with distinct emargination in posterior margin, hairs forming fringe of emargination rather short; lateral angles of sixth tergum obtuse and slightly rounded; lateral lobes of seventh tergum reduced to rounded shoulders, median tooth reduced to short, obtuse projection.

*Type*: female; Bluff Lake, San Bernardino Mountains, California, on loan deposit in the California Academy of Sciences. Additional specimens, apparently belonging to this species but slightly smaller than the type, are two females from the North Fork of Bishop Creek, Inyo County, California, 8500 feet elevation, June 22, 1937, one on *Phacelia* (C. D. Michener); one male, Glacier Lodge, near Big Pine, Inyo County, California, June 23, 1937 (E. C. Van Dyke); one male, Truckee, California, June 17, 1927 (E. P. Van Duzee); and one female, Mammoth, Mono County, California, July 25, 1936 (G. E. and R. M. Bohart).

### ***Anthocopa (Atoposmia) triodonta* (Cockerell)**

*Osmia (Atoposmia) triodonta* COCKERELL, 1935, Pan-Pac. Ent., 11: 50.

*Hoplitis triodonta* SANDHOUSE, 1939, Mem. Ent. Soc. Washington, 1: 140.

This is a rather large, robust species, closely resembling *pycnognatha* in the dense punctation, but differing markedly from that species by the longer, five-segmented maxillary palpi.

*Female*.—Length 7–8 mm. Pubescence white or grayish white. Punctures of head for the most part dense, although not confluent, those of clypeus but little coarser than those of frons; anterior ocellus about midway between posterior edge of vertex and antennal bases or but little posterior to midpoint; distance between posterior ocelli less than distance to posterior edge of vertex, which distance is less than that to eye margin; pubescence of cheeks abundant, depressed and directed forward; clypeal truncation simple or sometimes weakly sinuate so that there is a feeble rounded projection at each side of the middle, truncation about as long as distance from its rounded end to lateral angle of clypeus; mandibles slightly less than three times as long (measured along lower side) as shortest breadth, tridentate, notch between first and second teeth not prolonged into a sinus, sub-apical dorsal swelling rounded and distant from apex of third tooth by about half of shortest breadth of mandible; maxillary palpi as long as first segment of labial palpi, five-segmented, third segment much the longest. Thorax less closely and more coarsely punctate than

head, with a few fine punctures intermixed with the larger ones on mesoscutum and mesepisterna; enclosure of propodeum roughened above; inner hind tibial spurs distinctly bent at apices. Abdomen strongly punctate, punctures of middle of second tergum separated by more than their diameters; scopa yellowish white, elongate, longest hairs of second sternum twice as long as length of second tergum; apical pubescent bands of terga except the first complete.

*Male*.—Length 8–9 mm. Similar to female in appearance. Clypeus more finely punctate than rest of head; distance between posterior ocelli equal to or shorter than distance to eye margin, which distance is shorter than that to posterior edge of vertex; clypeal truncation not produced, over three times as long as distance from end of truncation to lateral angle of clypeus, truncation feeble crenulate. Third abdominal sternum with conspicuous, broad, fringed emargination; sixth tergum with an acute tooth at each side, lateral margins straight; seventh tergum with median tooth reduced to a mere angle, lateral lobes large and narrowly rounded.

### ***Anthocopa triodonta triodonta* (Cockerell)**

(Figs. 2, 12, and 25)

Punctures of cheeks in both sexes rather coarse, but little finer than largest punctures of vertex; impunctate anterior margin of clypeus of male very narrow.

*Type*: male; Mount Diablo, Contra Costa County, California, 3800 feet elevation. A topotype with the same data was collected by Dr. R. M. Bohart.

### ***Anthocopa triodonta usingeri*, n. subsp.**

Punctures of cheeks in both sexes finer than those of much of vertex and exceedingly dense; impunctate anterior margin of clypeus of male moderate in width.

*Holotype* male (Calif. Acad. Sci., Ent. No. 5166), allotype female (Calif. Acad. Sci., Ent. No. 5167) and four paratypes from Santa Rosa Mountain, San Jacinto Mountains, California, 5800 feet elevation, May 31, 1940, on *Pentstemon spectabilis*. Two paratypes, same locality, 6200 feet elevation, on *Nama parryi*, one May 31, 1940, the other June 11, 1940; seven paratypes, Vandevanter Flat, San Jacinto Mountains, June 11, 1940, on *Pentstemon spectabilis* (all C. D. Michener). Additional specimens are from Ribbonwood, San Jacinto Mountains, California, May 21, 1940 (C. D. Michener); Cajon Valley, San Gabriel Mountains, California, June 3, 1929 (E. G. Anderson). The original allotype female of *triodonta* from Lone Pine Canyon, San Gabriel Mountains, California, 5900 feet elevation, June 16, 1928, on *Pentstemon spectabilis* (P. H. Timberlake) belongs to *usingeri*.

This form is named for Dr. Robert L. Usinger, with whom I was collecting in the San Jacinto Mountain region when the type material was taken.

**Anthocopa (Atoposmia) shastensis** (Cockerell)

*Osmia shastensis* COCKERELL, 1935, Pan-Pac. Ent., 11: 46.

*Female*.—Similar to description of *A. triodonta* but pubescence of clypeus, mandibles, tibiae, and tergites except posterior margins largely black; scopa reddish, black laterally and posteriorly in some individuals; short appressed pubescence near eye margin dusky or blackish and therefore inconspicuous. Punctures of cheeks as in *A. triodonta triodonta*.

*Male*.—Differs from *A. triodonta* in the slightly coarser and less dense punctures of the cheeks, the fine and widely separated abdominal punctures (those of middorsal area of second tergum being separated by several times their diameters), and the presence of black hairs on the abdominal terga. The genitalia are apparently indistinguishable from those of *A. triodonta*.

*Type*: Female; Shasta County, California, in the Timberlake collection at the Citrus Experiment Station of the University of California, Riverside. Additional records: one female, Lake Almador, California, July 22, 1937 (F. X. Williams); one male, Summit Lake, Mount Lassen, California, 6700 feet elevation, July 21–22, 1937 (F. X. Williams); one male with abdominal punctation a little coarser than in the above male specimen, Carrville, Trinity County, California, 2400 to 2500 feet elevation, May 31, 1934 (G. E. Bohart).

This form is possibly a subspecies of *A. triodonta*, as has been suggested to me by Mr. P. H. Timberlake. The punctation of the cheeks and the width of the impunctate margin of the clypeus are as in *P. triodonta triodonta*, but the abdominal punctation of the male is much finer than in that species.

**Anthocopa (Atoposmia) pycnognatha**, n. sp.

(Fig. 29)

Although but slightly larger than *A. triodonta*, this robust species is the largest form in the subgenus. It may be distinguished easily from other species by the short, four-segmented maxillary palpi. The close punctation and broad, robust mandibles of the female suggest that this species is most closely related to *A. triodonta*, from which it differs by the convex lateral margins of the sixth tergum of the male, in addition to other characters.

*Female*.—Length nearly 8 mm. Pubescence brownish white; punctures of head for the most part dense, although not confluent, those of clypeus but little coarser than those of frons; anterior ocellus about midway between posterior edge of vertex and antennal bases; distance between posterior ocelli shorter than distance to posterior edge of vertex, which latter is shorter than distance to eye margin; pubescence of cheeks abundant, depressed and directed forward; clypeal truncation simple, about as long as distance from its rounded end to lateral angle of clypeus; mandibles slightly less than three times as long (measured from lower basal angle) as shortest breadth, tridentate, notch between first and second teeth not prolonged into a

sinus, subapical dorsal swelling rounded and distant from apex of third tooth by about half of shortest breadth of mandible; maxillary palpi four-segmented, little more than half as long as first segment of labial palpi, segments from longest to shortest being (2, 3) (1) (4). Thorax rather closely punctured, although not so closely so as head, and more coarsely so than head; enclosure of propodeum roughened above; inner hind tibial spurs distinctly bent at apices. Abdomen strongly punctate, punctures of second tergum except for small area medially separated by their diameters or less; scopa yellowish white, elongate, hairs of second sternum nearly twice as long as length of exposed part of second tergum; apical pubescent bands of terga complete except on first.

*Male*.—Length 9 mm. (varying to 8 mm. among paratypes). Similar to female in appearance and punctuation but clypeus more finely punctate than rest of head; distance between posterior ocelli less than distance to eye margin, which distance is less than that to posterior margin of vertex; clypeal truncation slightly produced, less than twice as long as distance from end to lateral angle of clypeus, demarked by distinct, slightly produced angles, median half of truncation finely denticulate; impunctate margin of truncation extremely narrow. Third abdominal sternum with conspicuous, broad, fringed emargination; sixth tergum with a tooth at each side, ending in a right angle, lateral margins of sixth tergum strongly convex; seventh tergum with median tooth hardly (if at all) exceeding rounded lateral lobes.

*Holotype* female (Calif. Acad. Sci., Ent. No. 5158), allotype male (Calif. Acad. Sci., Ent. No. 5159) and five male paratypes: Oak Creek Canyon, near Independence, Inyo County, California, June 11, 1937, on *Penstemon brevifloris* (C. D. Michener). One male and one female paratype no doubt from same locality but labeled merely Independence, Inyo County, California, June 11, 1937 (Bohart collection).

***Anthocopa (Atoposmia) panamintensis*, n. sp.**

(Figs. 3, 4, 14, and 24)

A moderate sized, rather slender species, easily distinguished from all other known forms by the quadridentate mandibles and modified clypeal margin of the female and the nearly straight median portion of the apical margin of the third sternum of the male.

*Female*.—Length 7 mm. Pubescence white or grayish white. Punctures of head nowhere dense, in most areas separated by slightly less than half their diameters, those of clypeus little if at all coarser than those of frons; anterior ocellus nearer to posterior edge of vertex than to antennal bases, distance between posterior ocelli equal to distance from posterior ocellus to eye margin, and equal to distance from posterior ocellus to posterior margin of vertex; pubescence of cheeks sparse, suberect; clypeal truncation rounded at ends, shorter than distance from its end to lateral angle of clypeus, furnished medially with a pair of teeth demarking a small, deep median emargination; mandibles more than three and one-half times as long

(measured from lower, basal angle to apex) as shortest breadth, quadridentate, notch between first and second teeth prolonged into a narrow sinus, fourth tooth shorter than others; maxillary palpi as long as first segment of labial palpi, five-segmented, segments, from longest to shortest, being (3, 4) (2) (1) (5). Thorax with punctures of disk of mesoscutum and of mesepisterna coarser and sparser than those of head, with a few minute ones interspersed among them; margins of mesoscutum with finer, closer punctures; enclosure of propodeum conspicuously although finely roughened above; inner hind tibial spurs but feebly bent at apices. Abdomen rather strongly punctate, punctures of median part of second tergum separated for the most part by less than twice their diameters; scopa white, short, longest hairs of second sternum shorter than length of exposed portion of second tergum; apical pubescent bands of terga broadly broken medially.

*Male*.—Length 7 mm. (6 mm. in one paratype). Similar to female in appearance and in punctation but clypeus considerably more finely and closely punctate than rest of head and sides of vertex rather closely punctate; distance between posterior ocelli equal to distance from one of them to posterior edge of vertex, greater than distance to eye margin; clypeal truncation feebly, irregularly crenulate, rather broadly impunctate, about twice as long as distance from its rounded ends to lateral angle of clypeus. Third abdominal sternum with broad, very shallow emargination on posterior margin, furnished with a conspicuous fringe; sixth tergum with a tooth at each side ending in about a right angle (sometimes slightly acute or obtuse); lateral margins of sixth tergum conspicuously convex; seventh tergum with median tooth broad and obtuse, exceeding lateral lobes, which in the allotype are greatly reduced.

*Holotype* female (Calif. Acad. Sci., Ent. No. 5160), allotype male (Calif. Acad. Sci., Ent. No. 5161), one female paratype, and seven male paratypes: Tuber Canyon, Panamint Mountains, Inyo County, California, 8000 feet, June 18, 1937, on damp ground beside a small spring (C. D. Michener).

An additional male specimen from Wild Rose Canyon, Panamint Mountains, Inyo County, California, 7500 feet, June 18, 1937, differs from the others primarily in the absence of a median tooth on the seventh tergum.

#### Subgenus *Eremosmia*, n. subg.

Type species: *Osmia robustula* Cockerell.

Black without metallic tints; eyes with inner margins subparallel or but feebly converging below in females, diverging below in males; mandibles of both sexes tridentate, those of female slender, more than four times as long as shortest breadth; trophi short, when folded not reaching behind fore coxae, first segment of labial palpi over half as long as second; longitudinal carina of inner ventral angle of posterior coxae strong; scopa of female not elongated, male with second sternum somewhat to much enlarged; sixth tergum of male with a tooth or

angle at each side, seventh tergum exposed, with a median apical tooth.

This is a subgenus which has thus far been found only in the desert regions of eastern California.

#### KEY TO THE SPECIES OF THE SUBGENUS EREMOSMIA

##### FEMALES

1. Abdominal terga wholly black, punctation extending to their extreme posterior margins (p. 67).....**malloagnatha**  
Abdominal terga with posterior margins brown or reddish, narrowly impunctate.....2
2. Upper part of clypeus strongly convex, shining, and largely impunctate; distance between first two mandibular teeth considerably less than distance from second to third tooth (p. 68).....**laevibullata**  
Upper part of clypeus punctate, less strongly convex; distance between first two mandibular teeth equal to or greater than distance between second and third.....3
3. Femora red; punctures of center of scutum little if at all larger than coarser punctures of vertex.....4  
Femora black; punctures of center of scutum markedly coarser than those of vertex.....5
4. Abdomen largely covered with appressed, white pubescence; clypeus without a longitudinal, median impunctate area (p. 69).....**timberlakei**  
Abdomen with white pubescence primarily confined to posterior margins of tergites; clypeus with longitudinal, median impunctate band (p. 70),  
**nitidivitta**
5. Mandibles with subapical swelling of inner margin large and ending distally in a right angle; clypeus and mandibles black (p. 71).....**robustula**  
Mandibles with subapical swelling of inner margin feeble and rounded; mandibles largely red, anterior margin of clypeus red (p. 72).....**rupestris**

##### MALES

1. Penultimate antennal segment longer than broad; mandibles with distance between apices of first two teeth nearly twice distance between apices of second and third teeth (p. 71).....**robustula**  
Penultimate antennal segment broader than long; mandibles with apices of teeth nearly equidistant.....2
2. Femora red; punctures of cheeks and mesepisternum about equally coarse (p. 70).....**nitidivitta**  
Femora black; punctures of cheeks much finer than those of mesepisternum (p. 72).....**rupestris**

#### ***Anthocopa* (*Eremosmia*?) *malloagnatha*, n. sp.**

This is a rather large, coarsely punctate, black species, with but little pale pubescence. The parallel sided abdomen gives it the aspect of a species of *Phaeosmia*. However, although the male is unknown, I place this species in *Eremosmia* because of the slender mandibles and parallel inner margins of the eyes. In *Phaeosmia* it resembles *A. enceliae*, from which it differs, in addition to the characters mentioned above, by the reduced pubescence. In *Eremosmia* it is possibly closest to *laevibullata*, from which it differs in larger size, coarser punctation, punctate upper part of clypeus and posterior margins of terga, etc.

*Female*.—Length  $7\frac{1}{2}$  mm. Pubescent sparse, whitish, brushes of short hair under margin of clypeus and large dense tuft on outer surface of each mandible near apex orange; pubescence of tergites except for white bands at posterior margins light fuscous. Inner



orbits of eyes practically parallel; clypeus produced to a broad, gently concave truncation with rounded ends, truncation about as long as distance from its end to lateral angle of clypeus; produced closely punctured region of truncation with surface (seen in profile) directed anteriorly, at an angle to the rest of the clypeus which is convex and less closely punctured; head coarsely punctured, punctures (except for frons where they are closer) for the most part slightly separated by shiny ground, those of clypeus about twice as large as those of sides of face and supraclypeal area, but little larger than those of frons and vertex; median ocellus but little posterior to midpoint between posterior edge of vertex and antennal bases; distance between posterior ocelli slightly less than distance to eye margin, which is slightly less than that to posterior edge of vertex; second mandibular tooth approximately equidistant between first and third teeth; maxillary palpi four-segmented, segments two and three subequal and long, first shorter, fourth shortest, broad oval. Thorax coarsely and densely punctate, anterior median portion of mesoscutum with a small area of widely separated punctures, punctures of scutum coarser than those of vertex, as coarse as those of clypeus, those of mesepisterna coarser than those of scutum especially below; enclosure of propodeum roughened above; tegulae black; hind tibial spurs feebly curved apically; wings brownish. Abdominal terga strongly punctured, punctures middorsally mostly separated by two or three times their diameters but those near apical margins of terga (which are wholly black) finer and closer; posterior margins of terga one to four with very narrow, inconspicuous bands of white pubescence laterally; scopa yellowish white.

*Holotype* (Calif. Acad. Sci., Ent. No. 5162): seven miles west of Lone Pine, Inyo County, California, June 2, 1937 (C. D. Michener).

***Anthocopa (Eremosmia) laevibullata*, n. sp.**

(Fig. 10)

This small, fine punctate species lacks the *Phaeosmia*-like aspect of *mallognatha*, but is nevertheless perhaps more closely related to that species than to any other, as indicated in particular by the shape of the clypeus. It differs from that form by the smaller size, finer punctation, impunctate upper convexity of the clypeus, impunctate posterior margins of the abdominal terga, etc.

*Female*.—Length nearly 7 mm. ( $5\frac{1}{2}$  mm. in paratype). Pubescence dull whitish, that of dorsum of abdomen, except for posterior margins of tergites pale fuscous; anterior margin of clypeus and outer faces of mandibles without brushes or tufts of hair. Inner orbits of eyes feebly converging below; clypeus produced to a truncation, the ends of which are angulate, and the length of which is considerably less than distance from its end to lateral angle of clypeus; produced portion of clypeus coarsely longitudinally strigose punctate, directed anteriorly (as seen in profile) at an angle to rest of clypeus which is convex and nearly impunctate (with few scattered punctures) centrally; except for the clypeus whose punctures are coarse, the head is finely punctured, closely so on frons, but little less closely so elsewhere; median

ocellus much farther from antennal bases than posterior edge of vertex; distance between posterior ocelli equal to distance to posterior edge of vertex, less than distance to eye margin; mandible with inner subapical swelling feeble and gently rounded, second mandibular tooth separated from first by but little more than half distance separating it from third; maxillary palpi five-segmented, segments two to four subequal in length, one and five shorter. Thorax finely punctate, punctures of mesoscutum slightly finer than those of vertex and separated by about half their diameters; mesepisternum similarly punctured, much more sparsely so below; enclosure of propodeum roughened above; tegulae black; hind tibial spurs feebly curved apically; wings slightly grayish. Abdomen rather strongly punctured, middorsal portion of second tergum with punctures separated by two or three times their diameters; posterior margins of terga feebly brownish, narrowly impunctate, provided with distinct narrow bands of white pubescence, that of first tergum broken medially; scopa brownish white.

*Holotype* (Calif. Acad. Sci., Ent. No. 5169): Truckee, California, June 14, 1927 (E. P. Van Duzee). One paratype, Lake Spaulding, Nevada County, California, June, 1938, on pussy-paws (I. McCracken).

***Anthocopa (Eremosmia) timberlakei* (Cockerell)**

*Osmia timberlakei* COCKERELL, 1935, Pan-Pac. Ent., 11: 41.

This species is easily distinguished from others in the genus by the red femora, appressed pale pubescence covering almost the entire dorsum of the abdomen, and the closely punctured clypeus.

*Female*.—Length  $7\frac{1}{2}$ –8 mm. Pubescence dull whitish, brushes of hair under margin of clypeus and tuft of hair on outer face of mandible, subapically, small and orange. Inner margins of eyes parallel; anterior margin of clypeus produced to a very feebly concave truncation with broadly rounded ends; produced portion of clypeus not much directed anteriorly, rather densely punctured, punctures of clypeus little if any larger than those of sides of face and frons but markedly larger than those of vertex and cheeks; median ocellus somewhat posterior to midpoint between antennal bases and posterior edge of vertex; distance between posterior ocelli greater than distance to posterior edge of vertex, which distance equals that to eye margin; mandibles red subapically, apex of second tooth slightly nearer third tooth than first; maxillary palpi five-segmented, second and third segments subequal in length and longer than any of the others, fourth segment somewhat shorter, fifth yet shorter. Thorax finely and rather closely punctate, mesoscutum with punctation similar to that of vertex, mesepisternum with punctures considerably coarser and sparser, especially below; enclosure of propodeum shining to upper margin except laterally; femora red; tegulae rufotestaceous; hind tibial spurs curved apically; wings nearly clear. Abdomen with fine punctures, those of middorsal region of second tergum separated by two to three times their diameters; posterior margins of terga narrowly brownish and more narrowly impunctate; abdominal terga covered with

appressed, white pubescence, first three terga with transverse mid-dorsal areas bare; scopa yellowish white.

*Type*: Opposite sand dunes (north of Palm Springs), road to Palm Springs, Riverside County, California, in the Timberlake collection at the Citrus Experiment Station of the University of California, Riverside, California. An additional specimen is from nine miles north of Adelanto, Mojave Desert, April 25, 1937, on *Astragalus fremontii* (P. H. Timberlake).

***Anthocopa (Eremosmia) nitidivitta*, n. sp.**

(Figs. 6, 16, and 26)

This species resembles *A. timberlakei* in the red femora, but differs from that species in the distinct pubescent bands on the posterior margins of the abdominal terga, and the more coarsely punctate clypeus which is furnished with a longitudinal impunctate line.

*Female*.—Length 7 mm. (varying to  $7\frac{1}{2}$  mm.). Pubescence dull whitish, brushes of hair under margin of clypeus and tuft of hair on outer faces of mandibles, subapically, small and orange. Inner margins of eyes parallel; anterior margin of clypeus reddish medially, produced to a truncation (with broadly rounded ends) which is markedly shorter than distance from end of truncation to lateral angle of clypeus; produced portion of clypeus not directed anteriorly; clypeus with longitudinal median impunctate band which is narrowed and elevated on apical half, punctures of clypeus large, somewhat elongated, separated by some shiny ground; punctures of frons and sides of face finer than those of clypeus, slightly separated, those of rest of head still finer and approximate; median ocellus somewhat posterior to midpoint between antennal bases and posterior edge of vertex; distance between posterior ocelli equal to distance to posterior edge of vertex, slightly greater than distance to eye margin; mandibles red, bases black, apices dark brown (or black); subapical inner swelling low and rounded; apex of second tooth slightly nearer apex of third than apex of first; maxillary palpi five-segmented, third segment longer than any other, second shorter, first, fourth and fifth still shorter and subequal. Thorax rather finely and closely punctured, mesoscutum with punctation similar to that of vertex, mesepisternum with punctures coarser and sparser than those of mesoscutum; enclosure of propodeum shining to upper margin except laterally; femora red; tegulae rufotestaceous; hind tibial spurs pale testaceous, curved apically; wings slightly dusky. Abdomen with fine punctures, those of middorsal region of second tergum separated by several times their diameters; posterior margins of abdominal terga brownish, narrowly impunctate, with broad bands of white pubescence; scopa whitish.

*Male*.—Length  $7\frac{1}{2}$  mm. (varying to  $6\frac{1}{2}$  mm.). Similar to female in appearance and pubescence; inner margins of eyes strongly diverging below; anterior margin of clypeus not reddish, but little produced, truncation rounded at ends and about six times as long as distance from its end to lateral angle of clypeus; punctures of clypeus finer than in female, impunctate band absent on lower part of clypeus; punctures of frons closer than in female, those of cheeks sparser than in female;

mandibles red except bases and apices, slender, width at third tooth greater than width at base, apex of second tooth slightly nearer apex of third than of the elongate first tooth; punctures of mesepisterna not coarser than those of mesoscutum, although sparser. Posterior margins of abdominal terga broadly translucent testaceous; sixth tergum produced to a slender median tooth; second sternum large, covering most of third, posterior margin feebly emarginate medially; third tergum without deep posterior emargination, but with median fringed section; fourth sternum produced posteriorly to a median, broadly rounded angle.

*Holotype* female (Calif. Acad. Sci., Ent. No. 5163) and one female paratype: six miles north of Wild Rose Canyon, Panamint Mountains, Inyo County, California, 5000 feet elevation, May 28, 1937, *Phacelia* (C. D. Michener). Allotype male (Calif. Acad. Sci., Ent. No. 5164) and two female paratypes: West side of Westgard Pass, Inyo County, California, May 27, 1937, one on *Parosela fremontii* (E. C. Van Dyke, C. D. Michener). Paratypes: one female near Kearsarge, Inyo County, California, May 25, 1937 (E. C. Van Dyke), one female and one male, Wild Rose Canyon, Panamint Mountains, Inyo County, California, 7000 feet elevation, May 27, 1937 (C. D. Michener), two females nine miles north of Adelanto, Mojave Desert, California, April 25, 1937, on *Astragalus fremontii* (P. H. Timberlake). Paratypes will be placed in the collection of Mr. P. H. Timberlake, the California Academy of Sciences, and the author.

### ***Anthocopa (Eremosmia) robustula* (Cockerell)**

(Figs. 5, 15, and 30)

*Osmia robustula* COCKERELL, 1935, Pan-Pac. Ent., 11: 44.

This is a robust, abundantly pubescent species, apparently the most common species of the subgenus, and the most abundant desert representative of the genus.

*Female*.—Length 7–8 mm. Pubescence white, brushes of hair under margin of clypeus short but broad and orange, mandibles with area of dense orange hairs on outer surface subapically. Inner margins of eyes very slightly diverging below; anterior margin of clypeus produced to a broadly rounded truncation with rounded ends, length of truncation about equal to distance from end of truncation to lateral angle of clypeus; produced portion of clypeus not directed anteriorly; head finely punctate, punctures but little separated, except those of apical half of clypeus which are coarse, and become widely separated as impunctate margin of truncation is approached; anterior ocellus midway between antennal bases and posterior edge of vertex; distance from posterior ocellus to eye margin less than distance between posterior ocelli, which distance is less than that to posterior edge of vertex; mandibles sometimes feebly reddish subapically, subapical inner swelling high and truncated right-angularly distally, apex of median tooth slightly nearer apex of third tooth than apex of the long first tooth; maxillary palpi five-segmented, second longest, third slightly shorter, fourth slightly shorter than third, first very short, fifth variable (minute to nearly as long as first). Thorax much more

coarsely punctate than head, punctures of mesoscutum coarse and nearly confluent, those of mesepisternum of the same size but more widely separated; enclosure of propodeum shining and impunctate to dorsal margin except laterally; tegulae dark testaceous; hind tibial spurs bent apically; wings nearly clear. Abdomen well punctured, central part of second tergum with punctures separated by little over a diameter; posterior margins of abdominal terga feebly brownish, narrowly impunctate, with broad bands of white pubescence; scopa white.

*Male*.—Length 7-7½ mm. Similar in appearance to female. Inner margins of eyes somewhat divergent below; anterior margin of clypeus but little produced, the truncation nearly five times as broad as distance from end of truncation to lateral angle of clypeus, margin of truncation slightly convex and strongly crenulate; face below anterior ocellus covered with long white hair so that surface sculpture cannot be seen; punctures of clypeus fine and close; subapical portion of mandibles reddish, apical tooth very long, its apex more than twice as far from apex of second tooth as latter is from apex of third tooth which is right angular or somewhat acute; thorax less coarsely punctate than in female; sixth tergum with very feebly produced, slightly rounded angles at the sides; seventh tergum almost hidden, apex broadly rounded; second sternum large, feebly emarginate posteriorly, almost entirely covering third, which is broadly and deeply emarginate posteriorly with a fringe in median part of emargination; fourth sternum broadly rounded posteriorly.

*Type*: female; from north of Indio, California, in the Timberlake collection, Citrus Experiment Station of the University of California, Riverside, California. Additional localities: Cathedral City, Riverside County, California, April 10, 1936, on *Parosela schottii* (C. D. Michener); Big Pine, Inyo County, California, June 8, 1937, on *Parosela polyadenia* (E. C. Van Dyke, C. D. Michener); near Kearsarge, Inyo County, California, May 25, 1937 (E. C. Van Dyke); Lone Pine, Inyo County, June 15, 1937, on *Parosela polyadenia* (E. C. Van Dyke, C. D. Michener).

The male of this species is here described for the first time.

### ***Anthocopa (Eremosmia) rupestris* (Cockerell)**

(Figs. 7, 17, and 31)

*Osmia rupestris* COCKERELL, 1935, Pan-Pac. Ent., 11: 46.

This is a rather sparsely pubescent species with the mandibles largely red, the anterior margin of the clypeus red and small parts of the legs red. The male here placed with it has never been collected with the female, so that the association of the two forms as sexes of one species is somewhat doubtful. However, no other female with which the male could be placed is known.

*Female*.—Length 6-8 mm. Pubescence dull white, brushes of hair under margin of clypeus orange, very long and broad; mandible without subapical tuft of hair on outer side. Inner margins of eyes slightly converging below; anterior margin of clypeus produced to a rounded truncation (margined with red) longer than distance from

end of truncation to lateral angle of clypeus, produced portion of clypeus not directed anteriorly; head rather finely and closely punctured throughout, clypeus more coarsely so than frons and vertex; anterior ocellus farther from antennal bases than from posterior edge of vertex; distance between posterior ocelli equal to or slightly less than distance to posterior edge of vertex, which is equal to distance to eye margin; mandibles red except for extreme bases and apices, apex of second tooth about midway between apex of first and of third tooth, inner subapical swelling practically absent; maxillary palpi four-segmented, second segment longest, third shorter, fourth shorter than third. Thorax less closely and more coarsely punctured than head, punctures of mesoscutum markedly coarser than those of vertex, those of mesepisterna coarser and sparser than those of scutum; upper part of enclosure of propodeum roughened except at the middle; tegulae rufotestaceous; extreme apices of femora and bases of tibiae, and apices of tibiae and bases of basitarsi reddish; posterior tibial spurs slightly curved at apices; wings brownish. Abdomen rather strongly punctured, punctures of center of second tergum separated for the most part by about twice their diameters; posterior margins of abdominal terga rather broadly reddish, narrowly impunctate, and clothed with rather inconspicuous bands of sparse white hair; scopa yellowish white.

*Male*.—Length  $6\frac{1}{2}$ – $9\frac{1}{2}$  mm. Similar in appearance to the female but face below antennae more densely covered with white pubescence; clypeus short, but little produced, truncation of apical margin not red, feebly concave, nearly six times as long as distance from its end to lateral angle of clypeus; inner margins of eyes strongly diverging below; distance between posterior ocelli less than distance to eye margin, which distance is less than that to posterior margin of vertex; mandibles unusually long and slender, wider at extreme base than elsewhere, second tooth with apex about midway between apices of first and third teeth, third tooth acute. Thorax less coarsely punctured than in female, mesoscutum punctured much like vertex, mesepisternum more coarsely so. Abdomen with dorsum very finely and sparsely punctate; sixth tergum with an inconspicuous, broad, obtusely rounded angle at each side; seventh tergum with an acute median tooth, the margin laterad to tooth convexly rounded; second sternum somewhat enlarged, only very feebly emarginate posteriorly; third sternum with posterior margin broadly and deeply emarginate, emargination fringed with very long hairs; fourth sternum with posterior margin broadly rounded.

*Type*: female, Big Rock Creek, California, in Timberlake collection, Citrus Experiment Station, University of California, Riverside, California. Additional specimens: one male, Tahquitz Canyon, near Palm Springs, California, on *Larrea divaricata*, March 24, 1936, (Dammers); one female, ten miles east of Mecca, California, April 14, 1935 (C. D. Michener); one female, Andreas Canyon, near Palm Springs, California, on *Eriodictyon crassifolium*, April 10, 1936 (C. D. Michener); three males, Mazourka Canyon, Inyo Mountains, Inyo County, California, 9500 feet elevation, June 1, 1937 (C. D. Michener).

Subgenus **Hexosmia**, n. subg.Type species: *Osmia copelandica* Cockerell.

With green and bronz metallic tints on body; eyes conspicuously converging below in both sexes; mandibles of male bidentate, of female tridentate, about three times as long (along lower margin) as shortest breadth; trophi rather short, when folded reaching fore coxae, not provided with hooked hairs; first segment of labial palpi about two-thirds as long as second. Longitudinal carinae of inner ventral angles of posterior coxae inconspicuous. Scopa of female not unusually elongated; male with second sternum very large and largely covering following sterna; sixth tergum broadly rounded, edentate; seventh tergum hidden by sixth, likewise broadly rounded.

This subgenus may be distinguished by the metallic color alone from all other American *Anthocopa*.

## KEY TO SUBGENUS HEXOSMIA

1. Distance between first and second mandibular teeth of female distinctly greater than that between second and third; maxillary palpi three segmented (p. 74)..... **phaceliarum**  
Distance between first and second mandibular teeth of female about equal to distance between second and third; maxillary palpi four-segmented..... 2
2. Tegulae rufotestaceous; female with punctures of middle of dorsum of second abdominal tergum separated for the most part by about twice their diameters (p. 76)..... **arefacta**  
Tegulae black or brownish black; punctures of dorsum of second abdominal tergum separated at most by but little more than their diameters..... 3
3. Punctures of middorsal area of second abdominal tergum in female separated for the most part by about their diameters (p. 75)..... **copelandica**  
Punctures of middorsal area of second abdominal tergum in female separated by much less than their diameters (p. 77)..... **albomarginata**

**Anthocopa (Hexosmia?) phaceliarum** (Cockerell)

*Osmia phaceliarum* Cockerell, 1935, Pan-Pac. Ent., 11: 45.

Since the male of this species is unknown its subgeneric position cannot be determined with certainty. Although it is not closely related to the other *Hexosmia*, which constitute a compact group, it has seemed best to place it in that subgenus for the time being because of the rather robust mandibles and greenish lustre.

*Female*.—Length about 6 mm. Pubescence white. Inner orbits converging below, clypeus densely punctured with apical truncation very feebly concave, demarked by rounded angles, and about as long as distance from end of truncation to lateral angle of clypeus; distance between posterior ocelli equal to distance to posterior edge of vertex, and equal to distance to eye margin; mandibles with apical half, except margin, red, the distance between the first and second teeth greater than that between the second and the acute third, notch between first and second rounded and deeper than that between second and third, subapical inner swelling, low and rather far from apex of third tooth; maxillary palpi very short, with three segments subequal in length, basal one about as broad as long, the two following increasingly slender. Upper part of enclosure of propodeum roughened;

tegulae bright ferruginous; wings dusky hyaline; abdomen with posterior margins of terga rufous and with narrow white hair bands, broken on terga one to three; scopa white.

*Type:* Puente Hills, near Whittier, California, in the Timberlake collection at the Citrus Experiment Station of the University of California, Riverside, California. The species is known only from the unique type.

***Anthocopa (Hexosmia) copelandica* (Cockerell)**

(Figs. 11 and 20)

*Osmia copelandica* COCKERELL, 1908, Entom., 41: 59; COCKERELL, 1910, Psyche, 10: 246; COCKERELL, 1919, Jour. N. Y. Ent. Soc., 27: 300; COCKERELL, 1928, Univ. Colo. Studies, 16: 124.

*Hoplitis copelandica* SANDHOUSE, 1939, Mem. Ent. Soc. Washington, 1: 139.

*Osmia besseyae* COCKERELL, 1910, Entom., 43: 92; COCKERELL, 1928, Univ. Colo. Studies, 16: 124.

This is a small, slender, feebly metallic species.

*Female*.—Length 6–8 mm. Pubescence white, brushes under margin of clypeus minute and whitish. Punctuation of head close, that of clypeus (except for broad impunctate margin of truncation) coarser than that of frons and vertex, that of lower parts of cheeks coarse and sparse; clypeal truncation somewhat concave, demarked by distinct angles, and conspicuously shorter than distance from its end to lateral angle of clypeus; cheeks slightly wider than eye seen from side; anterior ocellus much farther from antennal bases than from posterior margin of vertex; distance from a posterior ocellus to eye margin about equal to distance to posterior margin of vertex, distinctly greater than distance between posterior ocelli; mandibles stout, just over three times as long as shortest breadth, apex of median tooth about midway between apex of first and apex of third tooth; maxillary palpi four-segmented, second and third segments subequal and longer than others. Thorax a little less closely punctate than head, mesoscutum with punctures of same size as those of vertex, mesepisterna with punctures slightly larger; enclosure of propodeum roughened above; tegulae black or piceous; hind tibial spurs nearly straight; wings slightly dusky. Abdomen rather strongly punctured, punctures of center of second tergum separated by a little more than their diameters; posterior margins of terga feebly or not at all brownish, with distinct bands of white pubescence which are broken medially on first two or three segments; scopa white.

*Male*.—Length 6–7 mm. Similar in appearance to female; punctuation of clypeus similar to that of frons and vertex; truncation of clypeus shorter (less than two-thirds as long as distance from its end to lateral angle of clypeus) than in female, and more strongly concave, with stronger angles at its ends; distance between posterior ocelli equal to (or slightly greater or less than) distance to posterior margin of vertex or eye margin; mandibles short and robust, outer tooth a little longer than inner. Mesoscutum densely punctured and slightly more finely so than vertex. Sixth and seventh abdominal terga broadly rounded, the seventh visible only on dissection; second ster-



num rather large, with a short, median, apical emargination fringed with long hairs; longest hairs of genital coxopodites but little if any longer than width of coxopodite at subapical angle.

*Type*: female; Copeland Park, Boulder County, Colorado.

This is a widely distributed species, found from the coast of central and northern California to the Rocky Mountains. Colorado: Longs Peak Inn, 9000 feet elevation, June 30, 1926 (E. C. Van Dyke); Science Lodge, western Boulder County, July 20, 1939 (U. N. Lanham); four miles south of Grand Mesa, July 9, 1938 (R. Baner). Utah: Nephi, June 22, 1929 (E. G. Anderson). Oregon: Hanson's Resort, Jefferson County, July 29, 1929 (E. C. Van Dyke); Eagle Ridge, Klamath Lake, May 16, 1924 (C. L. Fox); Lake of Woods, Klamath County, 4950 feet elevation, August 11, 1935 (G. Ferguson). California: Mount Baldy, Panamint Mountains, Inyo County, June 19, 1937, on *Phacelia* (C. D. Michener); Argus Mountains, Inyo County, May 22, 1937 (N. W. Frazier); Independence Creek, Inyo County, 8000 feet elevation, June 17, 1937 (C. D. Michener); North Fork of Bishop Creek, Inyo County, 8500 feet elevation, June 22, 1937 (C. D. Michener); Mammoth Lake, Mono County, August 5, 1936 (G. E. and R. M. Bohart); Leavitt Meadows, Mono County, June 21, 1937; Truckee, June 13-21, 1927 (E. P. Van Duzee); Lake Tahoe, June 22, 1925 (E. H. Nast); Fallen Leaf Lake, Lake Tahoe, June 29, 1915 (E. C. Van Dyke); Gold Lake, Sierra County, August 4, 1921 (C. L. Fox); Shasta Springs, June 19, 1920 (C. L. Fox); Meadow Valley, Plumas County, 3500-4000 feet elevation, June 5-8, 1924 (E. C. Van Dyke); Big Flat, Coffee Creek, Trinity County, June 20, 1934 (G. E. Bohart); Sand dunes, San Francisco, June 25, 1925 (C. L. Fox).

### ***Anthocopa (Hexosmia) arefacta* (Cockerell)**

*Osmia arefacta* COCKERELL, 1935, Pan-Pac. Ent., 11: 42.

Like the following form, this species is closely related to *copelandica*. From the description of the latter, it differs thus:

*Female*.—Clypeal truncation but little concave; distance between posterior ocelli usually greater than distance to nearest eye margin, slightly less than distance to posterior edge of vertex; tegulae rufotestaceous; abdomen rather finely and sparsely punctured, punctures of middorsal area of second tergum separated by about twice their diameters; posterior margins of abdominal terga rather broadly reddish.

*Male*.—Tegulae rufotestaceous; posterior margins of abdominal terga reddish; punctures of terga slightly finer than in *copelandica*; genital coxopodites with longer hairs nearly twice as long as width of coxopodites at subapical angle.

*Type*: Palm Springs, California, in the Timberlake collection at the Citrus Experiment Station of the University of California.

Thus far this species is known only from the eastern desert foot of the San Jacinto Mountains. A new locality is Andreas Canyon, near Palm Springs, California, on *Phacelia*, April 10, 1936 (C. D. Michener).

However, two male specimens from Lancaster, California, June 10, 1936 (G. E. and R. M. Bohart) seem intermediate between *arefacta* and

*copelandica*. The tegulae are but little darker than in *arefacta*, the posterior margins of the abdominal tergites are dark, and the hairs of the genital coxopodites are intermediate in length between those of *arefacta* and those of *copelandica*. These specimens possibly represent a new species.

***Anthocopa (Hexosmia) albomarginata* (Cockerell)**

*Osmia albomarginata* COCKERELL, 1935, Pan-Pac. Ent., 11: 49.

This species is closely related to *A. copelandica*, from the description of which it differs only as follows:

*Female*.—Cheeks slightly narrower than eyes, seen from side; distance between posterior ocelli little if any less than distance to eye margin or to posterior margin of vertex; punctures of abdomen denser, those of middle of second tergum separated by much less than their diameters; posterior margins of terga not reddish.

*Male*.—Seemingly indistinguishable from *copelandica*.

*Type*: female; Swartout Valley, California, in Timberlake collection at the Citrus Experiment Station, University of California, Riverside, California.

This is a form of the mountains and coastal hills of southern California. It has been recorded from the Puente Hills. An additional locality is Tetley Park, San Bernardino Mountains, California, May 16, on *Nemophila* (C. D. Michener).

Subgenus ***Phaeosmia***, n. subg.

Type species: *Osmia enceliae* Cockerell.

Black, without metallic reflections; eyes converging below in both sexes or subparallel in males; mandibles of male bidentate, of female tridentate and less than four times as long (measured along lower margin) as shortest breadth; trophi rather short, when folded reaching fore coxae, not provided with hooked hairs; first segment of labial palpus two-thirds or somewhat less than two-thirds as long as second. Longitudinal carina of inner ventral angle of posterior coxa strong. Scopa of female not unusually elongated; male with second sternum large and largely covering the third; sixth tergum of male with an obtuse or rounded angle at each side, seventh hidden or largely hidden by sixth, rounded posteriorly.

This subgenus, like *Eremosmia*, is primarily an inhabitant of desert areas although one species (*hemizoniae*) occurs in coastal southern California. The bidentate mandibles and nearly hidden seventh tergite in the male indicate a relationship with *Hexosmia*, from which *Phaeosmia* differs by its larger size, non-metallic integument, strong posterior coxal carinae, etc.

KEY TO SPECIES OF PHAEOSMIA

FEMALES

1. Clypeal truncation about two-thirds as long as distance from its end to lateral angles of clypeus; ends of truncation marked by distinct, although narrowly rounded, angles (p. 78).....*mortua*
- Clypeal truncation about as long as distance from its end to lateral angles of clypeus; ends of truncation broadly rounded.....2

2. Apex of clypeus gently emarginate between broad, gently rounded lobes which form the ends of truncation; scopa yellowish white (p. 79), **hemizoniae**
- Apex of clypeus not or extremely slightly emarginate; scopa darker.....3
3. Distance between posterior ocelli equal to distance from a posterior ocellus to eye margin; anterior margin of clypeus directed forward, at distinct angle to lower disc of clypeus; scopa brown (p. 80).....**encelliae**
- Distance between posterior ocelli conspicuously less than distance to eye margin; anterior margin of clypeus not strongly directed forward; scopa pale ferruginous (p. 80).....**vigueriae**

## MALES

1. Inner ocular orbits converging to a point well below upper margin of clypeus (p. 80).....**encelliae**
- Inner ocular orbits converging only down to a point opposite antennal bases, below which they diverge slightly (p. 78).....**mortua**

**Anthocopa (Phaeosmia) mortua** (Cockerell)

(Figs. 8 and 18)

*Osmia vigueriae* var. *mortua* COCKERELL, 1935, Pan-Pac. Ent., 11: 44.

Although originally described as a variety of *vigueriae*, this form is a distinct species as is amply shown by the characteristics of the previously undescribed female.

**Female.**—Length  $7\frac{1}{2}$ –8 mm. Pubescence white, that of dorsum of head and thorax partly light fuscous, that of anterior margin of clypeus, that constituting short brushes under margin of clypeus and that which form a sparse subapical, outer tuft on each mandible orange. Punctuation of head rather coarse and in most areas dense, sparser and coarser on area of vertex behind ocelli; truncation of clypeus straight or nearly so, markedly shorter than distance from its end to lateral angle of clypeus, angles demarking ends of truncation distinct, although rather narrowly rounded; anterior margin of clypeal truncation rather broadly impunctate, not directed forward but in profile parallel to lower part of disc of clypeus; distance between posterior ocelli less than distance to eye margin and usually less than distance to posterior edge of vertex; anterior ocellus farther from antennal bases than from posterior edge of vertex; mandibles distinctly less than three times as long as shortest breadth, apex of second tooth nearer third than first tooth, subapical inner swelling strong and obtusely angulate; maxillary palpi four-segmented, second and third segments longest and subequal, first and fourth shorter. Thorax a little more coarsely punctate than most of head but not so coarsely so as posterior median part of vertex, punctures, even of mesepisterna, rather dense; upper part of enclosure of propodeum roughened; tegulae ferruginous; wings slightly dusky; posterior tibial spurs straight. Abdomen rather coarsely punctate, punctures of center of second tergum separated by more than their diameters, those of posterior margins of terga progressively finer and closer, no impunctate margins on terga; posterior margins of terga furnished with narrow but complete bands of white pubescence; scopa dull white.

**Male.**—Length nearly 6 mm. Similar in appearance to female. Inner ocular orbits subparallel, converging slightly toward antennal bases from both above and below; clypeus conspicuously more finely punctate than rest of head, anterior margin rather broadly impunctate,

truncation feebly crenulate, about five times as long as distance from its end to lateral angle of clypeus; area behind ocelli not more coarsely or sparsely punctate than rest of head; mandibles slightly narrowed at apices so that transverse breadth at apex of inner tooth is markedly less than breadth a short distance basad to that point; tegulae black with a reddish area; upper part of enclosure of propodeum smooth medially; sixth tergum with a rather narrow, posteriorly directed flange (which is sometimes brown) on the broadly rounded margin, sides of tergum each with a broadly rounded angle of varying prominence; second sternum rather large, narrowly subtruncate medially; third sternum broadly emarginate, emargination fringed with long hairs; fourth sternum broadly rounded posteriorly.

*Type*: male; Townsend Pass (or Emigrant Pass?) near Death Valley, Inyo County, California, 3000 feet elevation, in the Timberlake collection at the Citrus Experiment Station at Riverside, California. Additional specimens are from near Darwin Falls, Argus Mountains, Inyo County, May 30, 1937 (C. D. Michener); Wild Rose Canyon, Panamint Mountains, Inyo County, 3500 feet, May 28, 1937 (C. D. Michener); Mazourka Canyon, Inyo Mountains, Inyo County, May 25, 1937 (N. W. Frazier); Westgard Pass (west side), Inyo County, June 3, 1937 (E. C. Van Dyke), and same locality, June 15, 1937, on *Encelia farinosa* (C. D. Michener).

***Anthocopa (Phaeosmia) hemizoniae* (Cockerell)**

*Osmia hemizoniae* COCKERELL, 1935, Pan-Pac. Ent., 11: 47.

This is the largest species of *Phaeosmia*, and differs from the others by the weakly bilobate condition of the margin of the clypeus.

*Female*.—Length 9 mm. Pubescence yellowish white, brushes under margin of clypeus and subapical brushes of mandibles reduced; punctuation of head rather fine and dense, that of clypeus, except for the broad impunctate apical margin, coarser than that of frons and vertex; distance between posterior ocelli slightly less than distance to eye margin and distinctly less than distance to posterior edge of vertex; anterior ocellus about midway between antennal bases and posterior edge of vertex; truncation of clypeus not well demarked at ends, broadly rounded at each side, forming a median emargination; mandibles just over three times as long as shortest breadth, median tooth apparently equidistant between apices of first and third teeth. Thorax rather closely punctate, even on mesepisterna, and more coarsely so than head; enclosure of propodeum not roughened above medially; tegulae black with brown spot; wings slightly dusky; posterior tibial spurs straight. Abdomen strongly punctured, punctures of center of second tergum separated by less than their diameters; posterior margins of terga black, furnished with narrow bands of white hair, not impunctate but punctures finer than elsewhere on abdomen; scopa yellowish white.

*Type*: Riverside, California, in the Timberlake collection at the Citrus Experiment Station of the University of California at Riverside. Additional specimens are from Santa Monica, California, June 26, 1935 (E. G. Linsley).

**Anthocopa (Phaeosmia) enceliae** (Cockerell)

(Figs. 9 and 19)

*Osmia enceliae* COCKERELL, 1935, Pan-Pac. Ent., 11: 43.*Osmia viguierae* COCKERELL, 1935, Pan-Pac. Ent., 11: 44. (♂, nec ♀.)

In its coarse punctuation, this species resembles *mortua*, from which it differs in the black tegulae, more broadly truncate clypeus, etc.

**Female.**—Length 7–8 mm. Pubescence white, rather large brushes under margin of clypeus and tufts on outer surfaces of mandibles reddish; anterior ocellus farther from antennal bases than from posterior edge of vertex; distance between posterior ocelli equal to distance to eye margin, and to distance to posterior margin of vertex; punctuation of head coarse and close, that of clypeus coarser than that of frons and most of vertex; anterior part of clypeus coarser than that of frons and most of vertex; anterior part of clypeus directed a little forward, at a distinct angle to the somewhat receding lower part of disc; mandibles nearly four times as long as shortest breadth, middle tooth with apex about equidistant between apex of first and of third tooth, inner subapical swelling of mandible conspicuous but rounded; maxillary palpi four-segmented, second and third segments longest and subequal. Thorax coarsely and densely punctured, the mesoscutum more coarsely so than vertex; enclosure of propodeum not roughened medially above; tegulae black; wings slightly dusky; hind tibial spurs black and nearly straight. Abdomen strongly punctured, punctures of middorsal area of second tergum separated by more than their diameters; posterior margins of terga black, finely punctate, and furnished with narrow bands of white pubescence; scopa brown.

**Male.**—Length 7–8 mm. Similar in appearance to female. Punctuation throughout finer than in the female; distance between posterior ocelli equal to distance to eye margin but less than distance to posterior edge of vertex; clypeus markedly more finely punctate than rest of head, the broadly impunctate and rather distinctly crenulate margin of truncation nearly four times as long as distance from end of truncation to lateral angle of clypeus; mandible but little narrowed at apex, width at tip of inner tooth but little less than width a short distance basad to this point. Abdomen with sixth tergum broadly rounded at apex, with a narrowly projecting brownish flange on the margin, and with a broadly rounded angle at each side; second sternum large, with feeble median apical emargination; third with broad apical emargination fringed with long hairs, fourth broadly rounded.

**Type:** female; Andreas Canyon, near Palm Springs, California, in the Timberlake collection at the Citrus Experiment Station, Riverside, California. A pair of topotypes were collected by the author, April 10, 1936, on *Encelia farinosa*.

**Anthocopa (Phaeosmia) viguierae** (Cockerell)*Osmia viguierae* COCKERELL, 1935, Pan-Pac. Ent., 11: 44. (♀, nec ♂.)

Although this species and *enceliae* have been collected in the same locality and not elsewhere, they appear to be distinct but closely related forms. Males of but one species of *Phaeosmia* are known from this locality. While Cockerell placed them in *viguierae*, it seems probable, as

suggested to me by Mr. Timberlake, that they belong to the more common type of female, namely *enceliae*. Thus the true male of *viguierae* is unknown.

*Female*.—Similar to *enceliae* but more finely punctate, especially so on clypeus; anterior margin of clypeus but little directed forward, nearly parallel with lower part of disc of clypeus; second mandibular tooth nearer to first than to third; distance between posterior ocelli conspicuously less than distance to eye margin or to posterior edge of vertex. Scopa pale ferruginous.

*Type*: Andreas Canyon, near Palm Springs, California, in the Timberlake collection at the Citrus Experiment Station, University of California, Riverside.

### Subgenus *Xerosmia*, n. subg.

Type species: *Osmia xerophila* Cockerell.

Black, without metallic tints; eyes with inner margins converging below in both sexes; mandibles of male bidentate, of female tridentate, less than four times as long as shortest breadth; trophi short, when folded not reaching fore coxae, first segment of labial palpus about two-thirds as long as second, maxillary galeae and first two segments of labial palpi provided with numerous long hairs whose apices are hooked. Longitudinal carina of inner ventral angle of posterior coxa strong. Scopa of female not unusually elongated; male with second sternum not much enlarged, sixth tergum with a small tooth at each side, seventh tergum exposed and strongly tridentate.

Only the type species is placed with certainty in *Xerosmia*, although *A. palmarum* is included here tentatively, and in all probability correctly. This subgenus differs from all other *Anthocopa*, but resembles *Proteriades*, in the modifications of the mouthparts. These modifications are evidently associated with the flower visiting habits of these bees, their favored and only regular host being *Cryptantha*. It seems probable that *Proteriades* and *Xerosmia* are not closely related to one another, but that the similarity in mouth parts has arisen independently in the two groups.

### KEY TO THE SPECIES OF XEROSMIA

#### FEMALES

1. Second mandibular tooth much nearer to first than to third tooth; distance between posterior ocelli greater than distance from one of them to eye margin (p. 83) . . . . . **palmarum**  
 Second mandibular tooth about equidistant between first and third teeth; distance between posterior ocelli less than distance to eye margin (p. 81),  
**xerophila**

#### MALES

(Known only in *xerophila*.)

### *Anthocopa* (*Xerosmia*) *xerophila* (Cockerell)

(Fig. 21)

*Osmia xerophila* COCKERELL, 1935, Pan-Pac. Ent., 11: 45.

*Female*.—Length  $7\frac{1}{2}$ –8 mm. Pubescence dull white, that between white bands of dorsum of abdomen pale fuscous; brush arising

beneath margin of clypeus long, sparse, orange. Anterior margin of clypeus produced to a distinct, slightly concave truncation, shorter than distance from its end (which is angular) to lateral angle of clypeus; clypeus coarsely and not very closely punctate, margin of truncation impunctate; rest of head much more finely and closely punctate; anterior ocellus farther from antennal bases than from posterior edge of vertex; distance between posterior ocelli less than distance to eye margin which is equal to distance to posterior edge of vertex; mandibles reddish subapically a little over three times as long (measured along lower margin) as shortest breadth, apex of middle tooth little if at all nearer to apex of first than to apex of the acute third tooth, inner subapical swelling feeble; maxillary palpi four-segmented, third segment longest, second and fourth subequal in length. Thorax with mesonotum finely and closely punctured like vertex, mesepisterna more coarsely and less closely punctured; enclosure of propodeum roughened above; tegulae rufotestaceous; apices of femora and bases and apices of tibiae narrowly reddish; hind tibial spurs nearly straight; wings slightly grayish, especially apically. Abdomen coarsely punctured, punctures of middle of second tergum separated by about their diameters; posterior margins of terga rather broadly reddish brown, and furnished with rather conspicuous bands of white pubescence; scopa brownish white.

*Male*.—Length  $6\frac{1}{2}$ –9 mm. Similar in appearance to female but abdomen more elongate and parallel sided, the apex curled downward. Face rather densely covered with long, white pubescence; clypeus but little produced, its truncation nearly four times as long as distance from end of truncation to lateral angle of clypeus, margin of truncation broadly impunctate and weakly crenulate; clypeus otherwise fine and closely punctate; distance between posterior ocelli equal to distance to eye margin, slightly less than distance to posterior edge of vertex; antennae elongate, scape longer than mandible, flagellum slightly compressed, its segments, except for the penultimate one, longer than broad. Thorax similar to that of female; middle coxae each with a large, apical, ventral tooth directed posteriorly; carina of inner ventral angle of posterior coxae abruptly elevated in distal third. Abdomen with a small tooth at each side of sixth tergum; seventh tergum much exposed with a smooth transverse basal sulcus and three long apical teeth, the median one shorter and more slender than the slightly divergent, blunt pointed lateral ones, the lateral margin angulate beneath the bases of lateral teeth; first sternum with a large apical elevation, flattened on posterior face, summit slightly emarginate as seen from front or rear; second sternum not enlarged, feebly emarginate in middle of posterior margin; third and fourth sterna broadly emarginate and fringed with very long hairs; fifth sternum with a deep median emargination, the posterior margin laterad to emargination transverse; sixth sternum with a high longitudinal median keel, tapering anteriorly and ending in a sharp spine posteriorly.

*Type*: female; Palm Spring, Riverside County, California, in Timberlake collection at the Citrus Experiment Station of the University of

California at Riverside, California. Topotypes have been taken on March 22 (T. D. A. Cockerell) and April 16, 1939 (R. M. Bohart). The species is also known from Borego Valley. A number of specimens of both sexes have been reared by J. MacSwain from cells in old nests of *Anthophora linsleyi* Timberlake brought from Grape Vine Canyon (on the east side of the Sierra Nevada north of Walker Pass) Inyo County, California (G. E. Bohart).

***Anthocopa* (*Xerosmia*?) *palmarum* (Cockerell)**

*Osmia palmarum* COCKERELL, 1935, Pan-Pac. Ent., 11: 48.

Although this species was described from at least three specimens, only the holotype is now in the Timberlake collection. The mouth parts of that specimen are retracted, and it has not seemed wise to extract them. The male is unknown. Therefore, the subgeneric position of this species has remained in doubt. However, its other structures suggest a possible relationship with *A. xerophila*, and the occurrence of *palmarum* on *Cryptantha* lends weight to the idea that it may be a *Xerosmia*. For these reasons it is placed tentatively in that subgenus.

*Female*.—Length 5–5.7 mm. Pubescence largely dull white. Inner margins of eyes subparallel; truncation of clypeus nearly straight, terminated laterally by distinct angles, truncation somewhat longer than distance from its end to lateral angle of clypeus; distance between posterior ocelli slightly greater than distance to posterior edge of vertex, which distance is greater than that to eye margin; mandibles reddish subapically, second tooth much nearer to first tooth than to third. Tegulae reddish; wings hyaline. Posterior margins of terga reddish; scopa white.

*Type*: Palm Springs, Riverside County, California, in the Timberlake Collection at the Citrus Experiment Station of the University of California, Riverside, California. The species is also known from 19 miles west of Kane Springs, California.

## PART II

### OLD WORLD SUBGENERA OF ANTHOCOPA

In this section only those subgenera of which I have seen specimens are discussed. The names *Acanthosmia* Thomson, *Arctosmia* Schmiedeknecht, *Aspidosmia* Brauns, *Lithosmia* Alfken, *Megalosmia* Schmiedeknecht, and *Protosmia* Ducke are based upon species which I have not seen, and some of which very likely belong to *Hoplitis* or *Osmia* rather than to *Anthocopa*.

#### Subgenus ***Anthocopa*** Lepeletier, s. str.

*Anthocopa* LEPELETIER, 1825, Ency. méth. (Ins.), 10: 314.

Type species: *Apis papaveris* Latreille (monobasic).

*Phyllotoma* DUMERIL, 1860, Mem. Acad. Sci. Paris, 31: 843. MICHENER, 1941, Amer. Midl. Nat., 26: 180.

Type species: *Apis papaveris* Latreille, by designation of Michener, 1941.



*Furcosmia* SCHMIEDEKNECHT, 1886, Apid. Europ., 2: 888. COCKERELL, 1922, Am. Mus. Novit., 40: 6.

Type species: *Apis papaveris* Latreille, by designation of Cockerell, 1922.

*Pseudosmia* RADOSZKOWSKI, 1872, Horae Soc. ent. Ross., 8: 18. COCKERELL, 1922, Am. Mus. Novit., 40: 6.

*Pseudoosmia* RADOSZKOWSKI, 1872, Bull. Soc. Moscou, 48: 152.

*Pseudocosmia* RADOSZKOWSKI, 1886, Horae Soc. ent. Ross., 20: 14.

Type species: *Megachile cristata* Fonscolombe, by designation of Cockerell, 1922.

This is a rather large, Old World group. It has much the appearance of the American *Atoposmia*, from which it differs by the clypeus of the female, which is broadly rounded or broadly truncate and not greatly produced over the base of the labrum, and by the form of the abdominal terga and sterna of the male. The mandibles of both sexes are tridentate, those of the female rather robust and about three times or less than three times as long as shortest breadth. The trophi are variable in length, in *A. papaveris* only reaching the fore coxae when folded, but in *A. crenulata* extending well behind the fore coxae. The inner ventral carina on each posterior coxa is weak or nearly absent. The sixth tergum of the male has a tooth at each side, and the seventh is exposed and furnished with two long lobes on its posterior margin. The sterna of the male are relatively simple, the second not or but little enlarged, the third clearly visible throughout its breadth and not or but little emarginate posteriorly.

In addition to the type species this subgenus includes *A. crenulata* (Morawitz), *longispina* (Perez), and to judge by the figures and descriptions alone, *A. saundersii* (Vachal), *dalmatica* (Morawitz), *bipartita* (Friese), etc. The female of *A. cristata* (Fonscolombe) is a remarkable form with peculiarly modified, quadridentate mandibles and with the clypeus provided with a great subapical transverse crest. It might well be placed in a distinct subgenus, for which the name *Pseudosmia* is available.

#### Subgenus *Glossosmia*, n. subg.

Type species: *Osmia singularis* Morawitz.

This subgenus resembles *Anthocopa* s. str. and *Atoposmia*, but differs from both by the bidentate mandibles of the male.

Mandibles of male bidentate, of female tridentate and more than three times as long as shortest breadth; clypeus of female truncate at apex and produced well over base of labrum; trophi elongated, when folded reaching far behind anterior coxae; carinae on inner ventral angles of posterior coxae practically absent; anterior face of first abdominal tergum broadly concave, separated from dorsal face by a distinct line formed by the termination of the smooth anterior surface of the tergum scopa of female (at least in type species) elongate as in many *Atoposmia*; sixth tergum of male with a tooth at each side, seventh (in type species) with an elevated, produced median area and a large broad tooth at each side; second sternum of male not much if at all enlarged, the third being visible throughout its breadth.

In addition to *A. singularis* (Morawitz), this subgenus apparently includes *A. anthocopoides* (Schenck) and *A. cypriaca* (Mavromoustakis), which differ, however, from the type species in the shorter clypeus and

scopa and more slender mandibles of the female and the produced and rounded seventh tergum of the male.

Subgenus **Erythrosmia** Schmiedeknecht

*Erythrosmia* SCHMIEDEKNECHT, 1886, Apid. Europ., 2: 886. COCKERELL, 1922, Am. Mus. Novit., 40: 6.

Type species: *Osmia andrenoides* Spinola, by designation of Cockerell, 1922.

This subgenus was originally described as a subgenus of *Osmia*, and separated from other groups of that genus primarily on the basis of the red abdomen.

The clypeus of the female is broadly rounded at the apex, much overhanging the base of the labrum. The mandibles of the male are bidentate, of the female tridentate and (in type species) nearly three times as long as shortest breadth. The trophi, when folded, easily reach the fore coxae. Each posterior coxa is furnished with a conspicuous longitudinal carina on its inner ventral angle. The sixth tergum of the male is without a transverse subapical keel and is not toothed laterally, the seventh is partly exposed and bidentate at the apex. The second sternum of the male is enlarged and not fringed posteriorly, the third is provided with a broad, fringed emargination.

This subgenus is apparently most closely related to the American subgenera *Hexosmia* and *Phaeosmia*. *Anthocopa sybarita* (Smith) (= *fossoria* Pérez) and *A. lhotelleriei* (Pérez) are best placed in *Erythrosmia*, although both lack red abdominal areas and have the mandibles of the female more slender than in *A. andrenoides*.

Subgenus **Rhodosmia** Michener, n. subg.

Type species: *Osmia paradoxa* Friese.

Only a single species has thus far been recognized as belonging to this subgenus. The small size and red abdomen suggest the type species of *Erythrosmia*, from which it may be immediately distinguished by the short clypeus and absence of the third mandibular tooth in the female, and by the hidden seventh and tridentate sixth terga of the male.

Mandibles of male bidentate, of female short, scarcely broader basally than at narrowest point, over three times as long as shortest breadth, apically furnished with two teeth close together near outer margin, followed by a nearly straight apical margin which extends to the inner apical angle; trophi when folded reaching anterior coxae; clypeus short, that of female but little overhanging base of labrum, broadly truncate, distance from end of truncation to lateral angle of clypeus but half as great as length of truncation; posterior coxae each with longitudinal carina on inner, ventral angle; first abdominal tergum with concavity of anterior face margined above by transverse carina; first sternum of male large, overhanging much of second and furnished with a great median tubercle, both first and second sterna emarginate posteriorly; seventh tergum of male entirely concealed, sixth turned under and furnished with three large, broad teeth on posterior margin.

L. J. G. 1943

Since certain of the characters of *Rhodosmia* agree with those given by Ducke for his group *Protosmia*, I here designate *Heriades glutinosus* Giraud as the type species of *Protosmia*. This is the first of Ducke's species, and is one which he figured. With its close relatives, it is abundantly distinct from *Rhodosmia* since the mandibles of the female, in *Protosmia* as thus restricted, bear a single outer apical tooth, followed by a series of peg-like processes along the apical margin, which is thus pectinate.

#### Subgenus *Hoplosmia* Thomson

*Hoplosmia* THOMSON, 1872, Skand. Hymen., 2: 233. MICHENER, 1941, Amer. Midl. Nat., 26: 161.

Type species: *Apis spinulosa* Kirby, by designation of Michener, 1941.

This group is easily distinguished from all the others by the produced and angulate or spined axillae. The males have an irregularly dentate transverse, subapical keel on the sixth abdominal tergite. The mandibles of the female are short and broad, scarcely narrowed medially, and but little more than twice as long as shortest breadth. The mandible of the male are bidentate. The posterior coxae are furnished with strong carinae on the inner ventral angles of each.

Several diverse types are included in this subgenus; some (e. g. *bidentata* (Morawitz) and *anceyi* (Pérez)) have long mouthparts as in *Atoposmia*, others (e. g. *spinulosa* (Kirby) and *ligurica* (Morawitz)) have short mouth parts. On the basis of this and other characters, *Hoplosmia* might be broken into several subgenera, but with specimens of only four species at hand, I hesitate to do this.

#### Subgenus *Othinosmia* Michener, n. subg.

Type species: *Thaumatocoma*<sup>4</sup> *moniliferum* Cockerell.

This is an African group which has a transverse, subapical keel on the sixth tergum of the male, suggesting a relationship with *Hoplosmia*, from which it differs by the edentate axillae.

Mandibles of male bidentate; clypeus not produced over base of labrum, its apical margin with truncation much broader than distance from end of truncation to lateral angle of clypeus; trophi without hamate bristles, when folded easily reaching fore coxae; antennae of male (at least in type species) elongate, flagellum compressed, especially distally, the apical segments constricted at each end so that they are oval in outline; legs slender; posterior coxae each with a longitudinal carina on inner ventral angle; first abdominal tergum with a shallow basal basin, bounded above by a weak carina; second sternum of male large, largely covering following ones, its posterior margin with an emargination fringed with long hairs; sixth tergum of male with a rather smooth subapical keel, similar in size and position to that of *Hoplosmia*.

*Osmia calviniae* Cockerell, of which I have not seen the male, very likely also belongs to *Othinosmia*.

<sup>4</sup> *Thaumatocoma* is a little known Australian genus, probably in the Megachilinae.

## NOTES ON ECUADORIAN BUTTERFLIES. III.

### The Genus *Lymanopoda* Westwood (Satyridae)

F. MARTIN BROWN,  
Colorado Springs, Colorado

As commonly considered this genus is composed of a very varied group of species. It does not bear with close scrutiny for congenerity. Three generic names have been proposed for members composing it since the recognition of the first species, described in (1851) in the "Genera of Diurnal Lepidoptera." At that time Westwood placed the three members in two genera which he subsequently combined under one of the names proposed, *Lymanopoda*. In this action all later students concurred. Although the species *samius*, type of *Lymanopoda*, is superficially quite different from *obsoleta*, the type of *Sarromia*, structurally they are sufficiently alike to be considered congeneric. They represent the extremes in a series of variations. In 1892 Roeber proposed the name *Trophonina* for Butler's species *acraeida*. While this separation might be held valid by some lepidopterists I am inclined to ignore it. This species is, to be sure, unlike the others in the genus—excepting *venosa* and *malia*, strictly congeneric with *acraeida*—yet the differences other than color pattern are quantitative rather than qualitative. I dislike subgeneric designations and so follow Weymer in placing both *Sarromia* and *Trophonina* as synonyms of *Lymanopoda*. Others will disagree with me on this point. That is their privilege. However, one entire group of species usually included in the genus *Lymanopoda* is quite evidently misplaced in that genus. Superficially they might be left there but structurally they are so distinct that I feel it is necessary to set them apart as a different genus. They have been excluded from this discussion and will be taken up in another paper.

### *Lymanopoda* Westwood

(1851), Genera of Diurnal Lepidoptera 2: 401.

Genotype: *Lymanopoda samius* Doubleday & Hewitson.

*Structures of the Head.*—The eyes are lightly haired. The antenna is made up of 32 joints of which 11 or 12 form the club. The palpi are long, the second joint being longer than the combined first and third. They are clothed in long hair scales.

*The Forelegs.*—The prothoracic legs are strongly reduced. Although at least three joints are present, only one is visible to the unaided eye. They are deeply buried in long hair scales.

*Venation of the Forewings.*—The base of the radius is greatly swollen, of the cubitus moderately and the anal weakly so. The first and second radial branches originate before the end of the cell, the third well beyond it. The radius is five-branched. There is a

strong median stalk directed basad from the end of the cell. In *samius* and the blue species, the white group of species and *labda* and *ionius* of the brown species this stalk is posterior to the  $M_1$ ; in all others it is anterior to that vein. A short cross vein is present between the radius and  $M_1$ .

*Venation of the Hindwing.*—The bases of the radius and cubitus are slightly swollen. The cross vein between  $M_1$  and  $M_2$  is long and sharply curved near  $M_1$ .  $M_2$  lies only a little closer to  $Cu_1$  than to  $M_2$ .

*The Male Genitalia.*—These structures are quite variable. The uncus is shorter than the tegumen. It may be simple as in *samius* or bifurcate. The sub-scapium is more or less strongly chitinated. In some species it is very strongly so and pronged. The valves are generally small and equipped with a distal process and usually a dorsal one. These processes are toothed. The saccus is small. The aedeagus is long, rather heavy, more or less straight and sometimes spined or toothed.

The majority of the species of *Lymanopoda* (*sensu stricto*) are found in the temperate regions of the tropical forests of America. A few of them stray into the paramos and one or two may be restricted to those inhospitable regions. A few species are characteristic of the sub-tropical forests. Weymer recorded six species and forms from Ecuador in his resumé of the genus in Seitz' *Macrolepidoptera of the World*, V: 244-250. We have eleven from that country in our collections.

#### KEY TO THE SPECIES AND FORMS

1. Upperside: Forewings glistening blue with dark marginal markings..... 2  
Forewings brown, or white with dark markings (p. 90)..... 4
2. Underside: Forewing with a broad black discal zone flecked with blue scales and bearing some white spots..... *caerulata* Godman & Salvin  
Forewings ochraceous yellow with rusty markings and several white-pupilled dark spots..... 3
3. Upperside: A partial row of dark spots in the limbal area of the hindwing parallel with the margin..... *samius* Doubleday & Hewitson (1)  
The marginal dark band broad enough to engulf these spots,  
*hazelana* n. sp. (2)

#### THE SAMIUS GROUP

The type of the genus *Lymanopoda* Westwood belongs to this group of species. It is *samius* Doubleday and Hewitson.

##### 1. *L. samius* Doubleday and Hewitson (Fig. 1640, Pl. I)

(1851), *Genera of Diurnal Lepidoptera*, 2: pl. 67, f. 6 (*not f. 7*).

Type locality: Bogota, Colombia.

Range: Colombia (and Ecuador?).

Neither Whymper nor Stübel collected this species in the high mountains of Ecuador. Dognin reported it in collections made by the Abbé Gaujon in the old diocese of Loja (*Lepid. Loja et Env.*, p. 33, 1891). These specimens may well be the following new species. That part of Dognin's collection in the U. S. National Museum does not contain them. All of the specimens of *samius* that I have seen are from

Colombia where the insect seems to fly at moderately high altitudes in the central and eastern cordilleras. The genitalia of the male is figured (B1640) and may be recognized by the spur on the dorsal margin of the valves basad of the curved and toothed distal process, and by the teeth on the dorso-distal margin of the aedaeagus. Dr. A. Schultze-Rhonhoff has described a part of the life history of this species in *Iris* (43: 158).

2. *L. hazelana*, n. sp.

(Fig. 1623, Pl. I)

Type locality: Seville de Oro, Azuay, Ecuador, 2500 m., Feb. 15, 1939 (F. M. B.).<sup>1</sup>

Holotype: A male, no. B1623; deposited in the American Museum of Natural History.

*Upperside*.—The blue of this species is a little greenish when compared with *L. samius* D. & H. The dark margins are broad and contain fewer light spots than are found on that species, thus resembling to some extent *L. caeruleata* G. & S. The subapical blue spot is small and the three white specks marginal and caudad of it are inconspicuous. The broad dark margin of the hindwings is more uniform in width than that on *L. samius* D. & H. and there is no trace of the limbal black dots as such. A light powdering of bluish scales is evident through the middle of the dark band toward the anal angle.

*Underside*.—In general the coloring and pattern of this surface is the same as *L. samius* D. & H. and thus quite distinct from *L. caeruleata* G. & S. On the forewings the rusty markings across the cell are heavier on *hazelana* than on *samius*. All of the three subapical white species lack black margining scales and the three pupillated dark spots between the branches of the median, cubital and anal vein form a straight line and not an angle as in *samius*. On the hindwings the row of tiny black specks is situated about midway between the margin of the wing and the end of the cell. This row is parallel to the wing margin and thus differs from the similar row on *L. samius*, which is irregularly distant from the margin of the wing. At the base of the wing there is considerable dark scaling of a uniform character which is lacking from *L. samius*.

The male genitalia differ from those of *L. samius* D. & H. in several primary respects. The aedaeagus is free of teeth on the dorso-distal portion. The valves lack the spur anterior to the distal process on the dorsal margin. The distal process is curved less than 45° rather than 90° as in *L. samius*. The genitalia are figured (B1623, Pl. I). The genitalia of *L. caeruleata* are distinctly different. They are figured, B1684, Pl. I, and will be seen to be closer to *L. cinna* (B1674, Pl. I) than to either *samius* or *hazelana*.

<sup>1</sup>The stations noted are fully described and located in Brown, F. M., Ann. Ent. Soc. Amer., 34 (4): 809-851, 1941. The initials indicate the collectors, F. M. B. = F. M. & H. H. Brown; W. C.-M. = William Clarke Macintyre; J. E. S. = J. Eugene Schilling.

The species is named for my wife who collected it among the stunted shrubs and *Chusquea* on the dry slopes of Cerro Negro above Seville de Oro.

# KEY TO THE SPECIES AND FORMS

(Continued)

4. Upperside: White with darker markings. . . . . 5  
The forewings brown, markings restricted to ocelli (p. 94). . . . . 14
5. Upperside: A broad dark bar extending from the costal margin to the outer margin of the forewings at least across the discocellulars; or apex dark to the cell. . . . . 6  
No such bar. . . . . *galactea* Staudinger
6. Upperside: The dark bar (of 5) connecting with the outer margin. . . . . 9  
This bar not connected with the outer margin. . . . . 7
7. Underside: Hindwing light yellow. . . . . *lactea* Hewitson  
Hindwing whitish marked with rusty brown. . . . . 8
8. Upperside: Dark markings blackish-brown. . . . . 8A  
Dark markings rusty. . . . . *n. nivea* f. *sororcula* Thieme
- 8A. Upperside: hindwing with four distinct dark brown discal spots, *umbratilis* f. *leucotecta* Rosenberg & Talbot  
These spots lacking. . . . . 8B
- 8B. Upperside: Hindwing with a marginal row of slender dark triangles on the nervules, nervules scaled with brown. . . . . *kruegeri* Roeder  
Hindwing without such markings. . . . . *nivea nivea* Staudinger (4)
9. Upperside: White of the forewings reduced to a subapical patch, *huilana* Weymer  
White more extended. . . . . 9A
- 9A. Upperside: White restricted to a discal patch broadly bordered with black on the outer and costal margins and at the base; hindwings with broad black borders. . . . . *pieridina* Roeder  
White more extended. . . . . 10
10. Upperside: Outer margin of the forewing with at least an apical white spot. . . . . 11  
No white spots in the outer margin of the forewing. . . . . *h. tolina* Weymer
11. Upperside: Cell of the forewing filled by the dark costal margin, *palumba* Thieme  
Some white in the cell of the forewing. . . . . 12
12. Upperside: Dark bars along the  $R_s$  and  $Cu_s$  on the underside of the hindwing clearly visible from the upperside. . . . . *eubagioides*? Butler (3)  
Not so. . . . . 13
13. Upperside: Dark markings blackish brown. . . . . 13A  
Dark markings rusty. . . . . *n. melia* f. *sororcula* Thieme
- 13A. Upperside: Hindwing with a dark brown spot in the inner angle and brown dusting along the outer margin. . . . . *shefteli* Dyar  
Outer margin of hindwing lacking this brown marking. . . . . *n. melia* Weymer

# THE LACTEA GROUP

I have examined the male genitalia of six forms of the white *Lymanopoda* representing five species. They confirm the general opinion that these species are congeneric with the *samius* group and the dark species. The genitalia are quite variable, species to species, but within a species are rather stable. Subspecific differences occur but are always of a secondary nature. From the sampling of genitalia that I have studied these structures seem to offer a sound basis for the diagnosis of species in the genus. It is quite probable that a complete study will reduce some of the names held as species in the key to subspecific standing. Lack of material and the scope of this paper prevent such a study at this writing.

The armature of *L. galactea* Staudinger (B1639, Pl. I) is closer to that of *L. samius* D. & H. than that of any other of the white *Lymanopoda* that I have dissected. The structure of the genitalia of *L. huilana tolima* Weymer (B1638, Pl. I) and a species I believe to be *L. eubagioides* Butler (B1610, Pl. I) are similar but separable. The genitalia of *L. nivea* Staudinger (B1608, Pl. I) resembles the same structures of *L. ionius* W. & H. (B1636, Pl. I) and *L. labda* Hewitson (B1612, B1647, Pl. II). Thus the transition is made from the blue to the brown species through the white group.

The genitalia of *L. shefteli* Dyar (Fig. WDF., Pl. I) is very much like that of *L. galactea* Staudinger and the "species" may indeed be a form of that one. In 1914 Rosenberg & Talbot described a series of *Lymanopoda* from the Urubamba region of Peru under the name of *umbratilis*. These range from brown to white which the authors believe to be a single species. I have not seen these nor have they been figured. It may prove that *L. shefteli* Dyar and *L. umbratilis* f. *leucotecta* R. & T. are the same. They seem to be from the description. If this is the case the name of the species must be *shefteli* since it has some months priority. Dyar's paper was published July 22, 1913, while Rosenberg & Talbot's did not appear until March 31, 1914, although it appears in the Transactions of the Entomologist Society for 1913.

### 3. *L. eubagioides* Butler (?)

(Fig. 1610, Pl. I)

1873, Annals and Magazine of Natural History (4) 12: 220.

Type locality: Peru (Whitely).

Range: Peru, and Ecuador (?).

Ecuador: Hda. Talahua, Bolivar, 3100 m., April 29, 1939, 3 males (F. M. B.).

The three males that we took on the paramo of the western slope of the Andes are clearly not *nivea*. I assign them to this species with some doubt. I have no *bona fide* specimens of *eubagioides* for comparison. The male genitalia of my specimens (B1610) is easily recognized by the simple distal process on the valve and the bifurcate uncus. Some one with true *eubagioides* can easily verify or deny my identification.

### 4. *L. nivea nivea* Staudinger

(Fig. 1608, Pl. I)

1887, Exotische, Schmetterlinge 1: 232, pl. 83.

Type locality: "Quito," Ecuador.

Range: Probably from central Peru to central Colombia in the eastern cordillera.

Ecuador: Cerro Pasachoa, Pichincha, 3300 m., Nov. 12, 1938, 4 males, 1 female (F. M. B.). Minza Chica, Tungurahua, 3200 m., April 8, 1939, 5 males, 1 female (F. M. B.). Hda. San Rafael, Pichincha, 3000 m., Nov. 12, 1938, 1 male (F. M. B.). Pundoa, nr. Baños, Tungurahua, 2800 m., Dec. 1, 1938, 3 males (W. C.-M.).



This species was not collected in Ecuador by Whymper, Stübel or Gaujon (for Dognin). I cannot understand this unless we were particularly fortunate in arriving at the right places at the right time. All of our localities for this race are in the eastern Andes. The insects are never found far from *Chusquea*, the climbing bamboo. In this respect they differ from the preceding species. The *Pundoa* specimens were taken by David Laddey, one of Macintyre's collectors. The Pasachoa and San Rafael specimens are from the dry thickets at the upper margins of the grain fields and pastures of the hacienda San Rafael. The Minza Chica specimens were taken well within the temperate rain forest and are a little larger than the others.

4a. *L. nivea melia* Weymer

(Fig. 1609, Pl. I)

1912, Seitz' Gross-schmetterlinge der Erde 5: 245; pl. 52c3.

Type locality: Quindio Pass, Colombia, 3800 m., Sept.-Nov., 1939 (Fassl).

Range: Colombia and Ecuador in the western cordilleras.

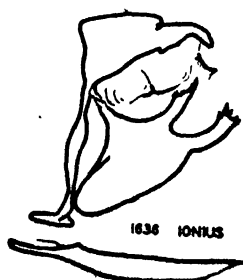
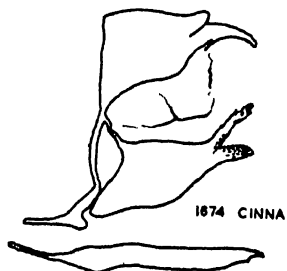
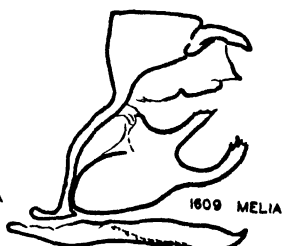
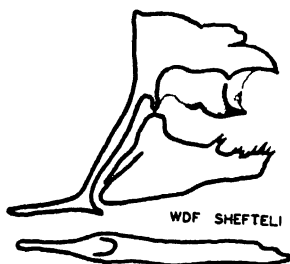
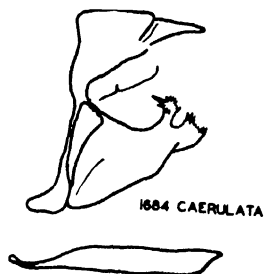
Ecuador: Hda. Talahua, Bolivar, 2900 m., May 5, 1939, 3 males (F. M. B.).

Our specimens were taken over *Chusquea* near the upper limit of a dense temperate rain forest. The genitalia (B1609) are practically inseparable from those of typical *nivea* (B1608).

In the *Berliner Entomologische Zeitschrift*, 49: 161, 1905, Thieme described *sororcula* from the "environs of Chimborazo" as a full species. Weymer treats this form as a race of *nivea*. I believe it to be a form which is common to both races, *nivea* and *melia*, but occurring infrequently at its fullest development. The females seem to be more susceptible to the rusty color replacing the black-brown than do the males. Until the type is examined and its racial affinity established it is best to consider the name a synonym of *nivea*. If it proves to be a form of *melia*, as I suspect from its type locality, the name *sororcula* must be used for the race in the western Andes as it has seven years priority.

The genitalia of the males of this species form the link with the following group of brown species. The dorsal spur of the valves is in this species developed into a full-fledged process bearing several teeth. The teeth on the aedaeagus readily distinguish it from *ionius* W. & H. and Ecuadorian *labda* Hewitson with which it might be confused solely on the basis of genitalia.

By far the majority of species of the genus are brown in color and constitute a part of the drably colored *Satyridae* that so few of the professional collectors bother to take. The following key to these may be helpful. It includes many species and forms that have not yet been recovered in Ecuador but I am sure that careful collecting will bring a number of them to light. This is especially true of the forms that haunt the temperate forests.



Genitalia of species of *Lymanopoda* Westwood.

# KEY TO THE SPECIES AND FORMS

(Concluded)

14. Upperside: A large green or blue area on the hindwing.....15  
     No such area.....16
15. Upperside: Hindwing with an area of blue.....*cinna* Godman & Salvin  
     Hindwing with an area of green.....*marianna* Staudinger
16. Upperside: Marginal patches of reddish orange on the forewing.....17  
     No such patches.....19
17. Upperside: These patches restricted to the midsection of the outer margin,  
     *venosa* Butler.....18  
     A full marginal row of patches.....18
18. Upperside: These patches absent from or forming only a partial row on  
     the hindwing.....*acraeida* Butler (11)  
     These patches forming full marginal rows on both wings.....*malia* Godman
19. Underside: A white or whitish band, or broken band, or row of spots  
     running diagonally across the hindwing from the anal margin to the  
     inner angle (exclusive of white-pupilled black submarginal spots).....20  
     No such band or spots; or an orange band.....24
20. Underside: A white or whitish transverse band on the hindwings,  
     *altis* Weymer (8).....21  
     A white or whitish row of spots or a broken band on the hindwing.....21
21. Underside: The white diagonal band on the hindwing slightly undulant,  
     sometimes just broken on the veins.....*albocincta* Hewitson (9).....22  
     This band a row of dots.....22
22. Underside: The white diagonal dots are in a straight line, except the  
     costal spot which is more basad; the pupillated spots of the forewing  
     more or less uniformly small and in a straight line.....23  
     The white spots do not form a straight line; the spots on the forewing  
     irregular in size, the two nearest the inner angle are quite large, the  
     line of spots is not straight.....*affineola* Weymer
23. Upperside: A discrete row of minute reddish submarginal specks on the  
     forewing.....*apulia* Hopffer  
     No such marks, occasionally a white speck on the forewing,  
     *albomaculata* Hewitson
24. Underside: An orange, toothed band extending from the anal angle to the  
     inner margin.....*Lymanopoda* (?) *levana* Godman  
     No such band present.....25
25. Underside: A bluish or whitish elongate spot, often pearly, in the lower  
     outer angle of the cell of the hindwing.....26  
     This spot absent or of just a lighter shade of the ground color.....32
26. Underside: The pearly silver spot in the cell forms the innermost spot of a  
     series of three or four curving from the cell to the inner margin near  
     the inner angle.....*labda* ♂ Hewitson (5).....27  
     These spots between the cell and the inner margin lacking.....27
27. Underside: The only other light spots on the hindwing are in a series  
     parallel to the margin.....27A  
     Other light spots present or the entire wing strongly mottled with dark  
     scales.....28
- 27A. Underside: A discal band of dark reddish-brown, narrowing to the inner  
     margin and sending out a streak to the anal angle,  
     *umbratilis* Rosenberg & Talbot  
     This band lacking.....*labda* ♀ (5)
28. Underside: The ground color of the hindwing more or less uniform and  
     a large light area extending from the  $M_2$  to the  $Cu_1$  inside of which  
     is a series of whitish spots.....*lebbaea* Felder  
     These light spots lacking.....29
29. Upperside: On the hindwing the light spots of the underside are visible  
     through the wing.....*translucida* Weymer  
     The hindwings are opaque.....30
30. Upperside: Forewing with a series of discrete whitish spots in the apex  
     and along the outer margin.....*hyagnis* Weymer  
     Lacking these spots.....31

31. Underside: A broad blackish band along the outer margin of the forewing curved away from the apex where it is margined externally with whitish. . . . . *rana* Weymer  
Without this band. . . . . *ferruginosa* Butler
32. Forewing: Outer margin well rounded with a slight reversed curve in the apex forming a slight apiculum. . . . . 33  
Outer margin straight or smoothly curved. . . . . 34
33. Upperside: Five white spots on the forewing forming a curved line, or a narrow white band. . . . . 43  
Two or less such spots. . . . . 33A
- 33A. Upperside: Two white spots on the forewing. . . . . *obsoleta* ♀ Westwood (6)  
At most only one minute, subapical white speck; base of the costa of the forewing rusty. . . . . *confusa* n. sp. (7)
34. Upperside: At least four pupillated eye-spots on the outer margin of the forewing, two near the inner margin large. . . . . 35  
These large eye-spots missing. . . . . 37
35. Upperside: The large eye-spots ringed with yellow, no spots on the hindwing. . . . . *albocincta* ♀ Hewitson  
The large eye-spots not ringed with yellow. . . . . 36
36. Underside: A row of eye-spots on the hindwing. . . . . *gortyna* Weymer  
No eye-spots on the hindwing. . . . . *panacea* f. *gortynoides* Weymer
37. Hingwing: Outer margin toothed. . . . . *Lymanopoda* (?) *maso* Godman  
Outer margin smooth or at most undulate. . . . . 38
38. Underside: Base of the forewing much lighter than the outer half, except the apex. . . . . *ionius* Westwood  
Base of the forewing no lighter and often darker than the outer half. . . . . 39
39. Upperside: Five large dark eye-spots on the forewing. . . . . 42  
Forewings without markings or with small obscure spots rarely more than three in number. . . . . 40
40. Underside: Distinct marginal row of white spots on both wings, none of the spots on the forewing broadly ringed with black. . . . . *caucana* Weymer  
Two of the posterior spots on the forewing broadly ringed with black. . . . . 41  
No such spots. . . . . *obsoleta* Westwood (6)
41. Underside: The small black submarginal spots on the hindwing ringed with bright reddish brown and often with white pupils, . . . . . *panacea* Hewitson (10)  
These spots usually with white pupils but without the reddish rings, . . . . . *venusia* Hopffer
42. Upperside: Hindwing with at least five large dark spots more or less paralleling the outer margin. . . . . *euopsis* Godman & Salvin  
Hindwing with rarely more than one dark spot near the margin, . . . . . *marica* Weymer
43. Hindwing: A blunt tail, 3 mm. long at "vein 4," . . . . . *Lymanopoda* (?) *caudalis* Rosenberg & Talbot  
Not tailed. . . . . *excisa* & ff.

I am not familiar with *L. nevada* Krueger (*Ent. Rdsh.*, 41: 7, 1924). This species may replace either *L. kruegeri* or *L. pieridina* of Roerber.

Note: *Lymanopoda varola* Schaus = *Manerebia cyclopina* Staudinger, *Lymanopoda villarresi* Dognin = *Euptychia villarresi* (Dognin), *Lymanopoda levana* Godman, *maso* Godman and possibly *caudalis* R. & T. may be out of place in this genus. I have not had the opportunity to examine them.

### THE CINNA GROUP

This group of three species, *cinna* Godman & Salvin, *marianne* Staudinger and *euopsis* Godman & Salvin, is not represented in collections from Ecuador and I doubt very much if it occurs there. It is distinctly aberrant in coloration and although the genitalia of *cinna*

(B1674) indicate that the species belongs to this genus the arrangement of the distal and dorsal processes on the valves is unusual as will be seen from the figure given. The genitalia of *euopsis* (Fig. B1679, Pl. I) are more normal and resembles those of *nivea*. With this species we have a transitional stage in the development of the pattern toward the *obsoleta* group.

## THE LABDA GROUP

### 5. *L. labda* Hewitson

(Figs. 1612 and 1647, Pl. II)

1861, The Journal of Entomology 1: 157; pl. 9, f. 4.

Type locality: Colombia.

Range: Colombia, Ecuador and Peru.

Ecuador: Runtún, nr. Baños, Tungurahua, 2800 m., Nov. 22, 1938, 2 males, (F. M. B.); 2500 m., Dec. 17, 1938, 1 male, (F. M. B.). Baños, Tungurahua, 1900 m., Oct. 22, 1939, 1 male, (W. C.-M.). Rio Ulva, nr. Baños, Tungurahua, 2500 m., Feb., 1939, 1 male, (J. E. S.); 1900 m., May 14, 1939, 1 male (W. C.-M.). Rio Blanco, nr. Baños, Tungurahua, 1800 m., April 5, 1939, 10 males (W. C.-M.); Yungilla, nr. Baños, Tungurahua, 1800 m., April 21, 1939, one male, (W. C.-M.).

The Rio Blanco and Yungilla specimens taken by Macintyre's native collectors probably came from much higher up the valley. I have a dozen or so species with these same data that we found nowhere under 2500 m. on the eastern slopes of the Andes. Dognin reported the species among those shipped him from the "environs of Loja." Neither Whympers nor Stübel collected the species.

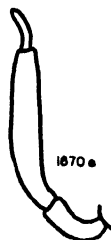
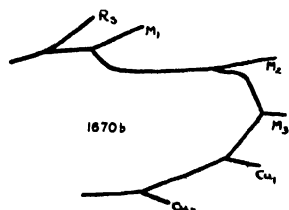
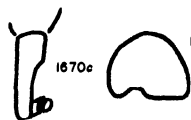
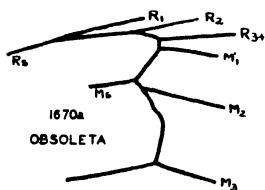
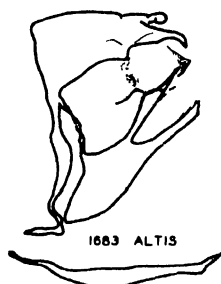
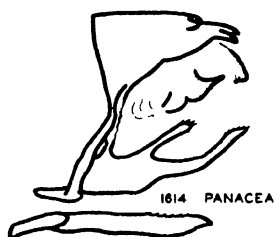
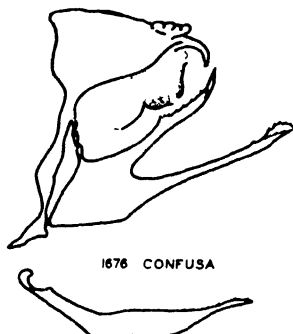
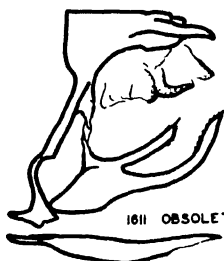
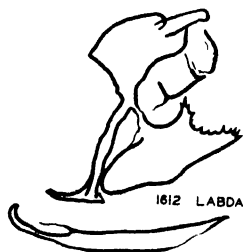
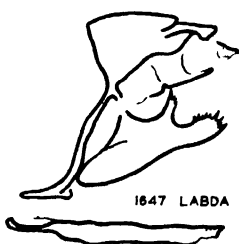
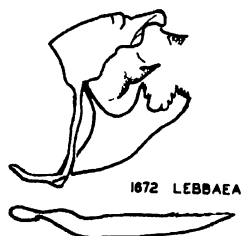
We found this species, like *nivea*, around *Chusquea*.

The male genitalia (B1612) may be recognized by the blunt tip on the uncus and the strongly toothed dorsal and distal processes on the valves. Colombian specimens (B1647) show a greater extension of the teeth in the "saddle" between the valvular processes than do the Ecuadorian specimens. This difference is supported by more extensive clear pearly white markings on the underside of the hindwings. The Peruvian specimens that I have seen have a much lighter ground color on the underside. I do not feel the need for designating these slightly differentiated choromorphs, since there is no possibility of confusing them with another species.

To this group I would assign the following species which have not as yet been found in Ecuador:

*L. lebbaea* Felder (B1672), (Fig. 1672, Pl. II). The male genitalia are very much like those of *labda*. In fact so much so that I would hesitate to separate the two species by that means alone. It might be best to consider it as a race of *labda*. The light colored specimens of this species from Peru approach *lebbaea* but are separable from it on the characters used in the above key, i. e., the isolation of the cellular pearly spot on the hindwing of *lebbaea*.

*L. ionius* Westwood (B1636), (Fig. 1636, Pl. I) is a species from the upper subtropical regions in Colombia that is quite distinct from *labda* in markings but close to it in the form of the male genitalia. Weymer's species *excisa* may be a form of this species.



Genitalia and other parts of species of *Lymanopoda* Westwood.

**L. ferruginosa** Butler from Bolivia and Peru is quite variable. Three subspecific names have been applied to it, *translucida*, *hyagnis* (B1641), and *rana*, by Weymer in Seitz' (5: 247). These are apparently tenable names from the specimens I have examined. However I would hesitate to designate the first two as racial. They, I feel, are forms of *ferruginosa* while *rana* appears to be a good race. The genitalia of all are so much alike as to be inseparable. These structures resemble those of *labda* in the form of the tegumen and uncus and *tolima* as to valves. Thus as far as these structures are concerned the species links the white and brown groups of the typical *Lymanopoda*.

### THE OBSOLETA GROUP

(1851), *Sarromia* Westwood, Genera Diurnal Lepid. 2: 402.

The species that constitute this group may be readily recognized by the peculiarities of the male genitalia. Although the general plan of these structures place the species in the genus *Lymanopoda*, the great length of the valvular processes and the heavy chitization of the subscaphium set them apart. The wing shape of some of the forms is aberrant. I have not examined *excisa* Weymer which may belong among these insects, but as I have stated above, I am inclined to feel that it is very closely allied to *ionius* Westwood.

#### 6. **L. obsoleta** Westwood and Hewitson

(Figs. 1611 and 1670 a-f, Pl. II)

(1851), Genera of Diurnal Lepidoptera, 2: pl. 67, f. 5, p. 402.

Type locality: Bolivia.

Synonym: *larunda* Hopffer, *Stettiner entomologische Zeitung*, 1874: 361; *larumna* Staudinger, *Iris*, 7: 72, 1894.

Range: Venezuela to Bolivia, in the mountains and higher foothills.

Ecuador: Runtún, nr. Baños, Tungurahua, 2800 m., Nov. 22, 1938, 4 males (F. M. B.); 2100 m., Nov. 26, 1938, 2 males (F. M. B.); 2000 m., Dec. 17, 1938, 3 males (F. M. B.); Feb. 27, 1939, 1 female (W. C.-M.); Oct., 1938, 1 male (W. C.-M.); 1900 m., Nov. 28, 1938, 1 male (F. M. B.). Pundoa, nr. Baños, Tungurahua, 2300 m., Dec. 1, 1938, 3 males (W. C.-M.). Rio Blanco, nr. Baños, Tungurahua, 2000 m., Oct. 18, 1938, 1 male (W. C.-M.); 1900 m., May 5, 1939, 2 males (W. C.-M.). Baños, Tungurahua, 2000 m., Jan., 1939, 4 males (J. E. S.); 2300 m., May 13, 1939, 1 male (W. C.-M.); Feb., 1939, 8 males, 1 female (J. E. S.); 1900 m., June 12, 1939, 1 male (W. C.-M.). Yungilla, nr. Baños, Tungurahua, 1700 m., May 27 and June 2, 1938, 2 males (W. C.-M.).

Weymer reported a specimen among Stübel's catch. It was taken at Pullulaga, north of Quito in the western cordillera at an altitude between 2500 and 2700 meters and between the 9th and 28th of July in 1873. Dognin reported the species as *larunda* among those collected by Gajon in the Loja region. Whympier did not take it.

This is another of the species that haunts the *Chusquea* thickets. It is found from the upper levels of the sub-tropical humid forest to the edge of the paramo. It seems to be much more common in the lower part of its range than the upper. There are occasional *Chusquea* thickets as low as 1400 m. in the valley of the Pastaza, but so far no

specimens have been turned up lower than 1700 m. The Baños specimens collected by Schilling (J. E. S.) were doubtless caught on Runtún. Those he collected in January he labelled from 2000 m., the February material bore no altitude note but probably came from the same place.

The species is the type of the genus *Sarromia* Westwood. When the immature stages are known it might be expedient to resurrect this genus. The species, *obsoleta*, is not strictly congeneric with *samius* D. & H., but is sufficiently close to allow the present arrangement to stand. The generally studied structures such as venation are like those of *samius* D. & H. These, of *obsoleta* W. & H. are figured B1670a-f.

7. *L. confusa* n. sp.

(Fig. 1676, Pl. II)

Type locality: "Ecuador."

Range: Colombia and Ecuador.

Holotype: a male, (B1676), ex coll. Frank Johnson "Ecuador."

Paratypes: No. 1, a male, ex coll. Dognin, Loja, Ecuad., June, 1886. No. 2, a male, ex coll. E. T. Owen, locality undecipherable. The preceding three specimens are in the U. S. National Museum. No. 3, a male, Choachi, Colombia, March, 1914, Acc. no. 5430, Carnegie Museum.

This species is very easily confused with *obsoleta* under which name it may be masquerading in other collections. In two easily observed minor ways it differs from *obsoleta*—the apex of the forewing is strongly falcate and terminates in a sharp point and the basad portion of the costal margin and the costad portion of the base of the forewings is bright rusty brown in contrast with the general dull brown of the upper surfaces.

The male genitalia (B1676) differ more from those organs of *obsoleta* (B1611) than do the male genitalia of *albocincta* (B1620) or *panacea* (B1614) differ from those of *obsoleta*. The most striking difference is to be found in the dorsal process of the valves. In *obsoleta* it is barely half as long as the distal process. In *confusa* it is almost as long as the distal process. The aedaeagus of *obsoleta* is free of distal spines while that of *confusa* bears a distinct disto-dorsal row of them.

The determination of this species can only be made certain by dissection unless the genitalia are protruding and can be examined. If after the present European conflagration the type of Hopffer's *larunda* is still extant in the Zoological Museum of the University of Berlin it will be possible to examine the genitalia of that insect and prove whether or not it is a synonym of *obsoleta* or this new species is a synonym of *larunda*.

8. *L. altis* Weymer

(Fig. 1683, Pl. II)

1890, Stübel's Reise, Lepidoptera, p. 41 and 109, pl. 3, f. 8.

Type locality: Paramo de Aponte, 2800 m., Nov. 25 to Dec. 11, 1869, So. Colombia.

Range: Colombia and Ecuador.

Ecuador: Runtún, nr. Baños, Tungurahua, 3000 m., Jan. 9, 1939, 4 males (W. C.-M.).



This species which Weymer described from material collected by Stübel in Colombia and Ecuador is placed by him in Seitz' close to "*L. leana*." It is far removed from that species and is a member of this group of *Lymanopoda*. I was unsuccessful in my search for it but while I was on the Rio Upano, David Laddey, one of Macintyre's collectors, turned up the four specimens in my collection. They were taken close to the limit of trees among *Chusquea* on the northeast shoulder of the Volcano Tungurahua. The genitalia of the male (B1683) are easily recognized by the great length of the dorsal process on the valves. This process exceeds the distal in length in this species.

#### 9. *L. albocincta* Hewitson

(Fig. 1620, Pl. II)

1861, The Journal of Entomology, 1: 157; pl. 9, f. 5.

Type Locality: Colombia.

Range: Colombia and Ecuador.

Ecuador: Balzapamba, Bolivar, 700 m., May, 1938, 1 male (W. C.-M.).  
Rio Toachi, Pichincha, 800 m., Nov., 1939, a male (W. C.-M.).

There is some discrepancy between the data on the specimens procured for me by Macintyre and the specimens I have seen from Colombia. The Colombian specimens are from altitudes that indicate that the species inhabits the cool upper reaches of the temperate forest. The data on the paper triangles in which my specimens arrived from Macintyre would indicate that the species was a denizen of the humid tropical jungle. The data on the Balzapamba specimens are probably correct. Macintyre and his crew were working that region at that time. The Rio Toachi specimen was from a lot purchased by Macintyre from a bird collector—one of the Olalla's?—in Quito. It contained a miscellaneous group of species, some of which are confined to the humid tropics and may well have been collected at Rio Toachi, 800 m., but others among it are restricted to the semi-arid paramos of the interandean plateau 2000 meters higher in altitude. So that the specimen here noted may have come from an altitude between 800 and 2800 meters on the western slope of the western cordillera. Thus the Rio Toachi data cannot be accepted at their face value. Dognin reported the species among those collected by Gaujon in "the environs of Loja." Four of Dognin's specimens are in the U. S. National Museum. Three are from "Loja" and one from "Zamora." As I have already stated, that means somewhere in southern Ecuador and not much more! It may have been taken high or low, on the east slope or the west, in dry or humid lands. Stübel did not collect this species in Ecuador. Coxey took a specimen at "Yungilla, nr. Baños, 4000 ft., March, 1930." This is the only reliable east slope record of which I have knowledge. Ecuadorian specimens differ slightly from those from Colombia in the width of the white spots on the underside of the hindwings.

Although the form of the wings and the general pattern of this species are quite distinct from *obsoleta*, the genitalia of the two species are much the same as are the other structures of the insects. The differences to be found in the genitalia are minor, and the uncus of *albo-*

*cincta* is bifurcate setting the species apart from *obsoleta* and the aedaeagus is free of teeth differentiating it from *panacea* and *albomaculata*.

### 10. *L. panacea* Hewitson

(Fig. 1614, Pl. II)

1869, Equatorial Lepidoptera, p. 35.

Type locality: "Ecuador."

Range: Colombia to Peru.

Ecuador: Chinchin Grande, Tungurahua, 1400 m., Oct., 1939, 1 male (J. E. S.). Abitagua, Napo-Pastaza, 1300 m., May 26, 1939, 1 male (W. C.-M.); June 2, 1939, 1 male (W. C.-M.). La Palmera, Tungurahua, 1300 m., Dec. 10-12, 1938, 3 males (W. C.-M.). Hda. San Francisco, Tungurahua, 1250 m., Sept. 20-24, 1938, 7 males (F. M. B.); Dec. 1, 1938, 2 males (F. M. B.); Jan. 28, 1939, one male (W. C.-M.); Mar. 7, 1939, a male (F. M. B.). Rio Margarjitas, Tungurahua, 1250 m., Mar. 19-23, 1939, 7 males (F. M. B.). Rio Topo, Napo-Pastaza, 1150 m., Sept. 30, 1938, one male (F. M. B.); Dec. 1, 1938, 1 male (F. M. B.). Rio Abonica, Santiago-Zamora, 1000 m., Jan. 21, 1939, 3 males (F. M. B.).

Hewitson's type was collected by Buckley, probably along the Baños-Canelos trail down the Rio Pastaza in the vicinity of the present Hda. San Francisco. Although Weymer did not report the species among Stübel's Ecuadorian material he gives Huamboya as a locality for it in Seitz' (p. 250). To my knowledge all Huamboya material was brought out by Stübel who purchased it from a native collector in Riobamba. Stübel's note regarding the locality is vague. Huamboya is the name given the ridge and general region lying east of Cerro Altar which is in turn east of Riobamba. Weymer's "Riobamba" specimens were doubtlessly collected by Feyer who thus dubbed many things that he caught along the Pastaza as he journeyed from the tropical forests to the arid temperate uplands that surround Riobamba. It is possible that Feyer collected the "Huamboya" specimen. The normal habitat of *panacea* is the subtropical humid forest.

I have carefully examined the male genitalia of *panacea* (B1614), *venusia*, *apulia*, *affineola* and *albomaculata* and find that there is no way to separate them. Thus I am led to believe that these forms along with *marica* and *caucana* represent a complex composed of one biological species. However, until this complex is more clearly understood it will probably be better to consider it to represent two taxonomic species—*panacea* and *albomaculata*. I believe that ultimately these two "species" will be considered races and the other named forms noted above will be either junked or considered local forms of a single species. I do not have the material to make a further study.

### THE ACRAEIDA GROUP

1892, *Trophonina* Roeder, Schatz & Roeder, *Die Fam. und Gattungen der Tagfalter*, p. 222, no 66.

There are two species in this group, *acraeida* Butler and *venosa* Butler. The former is found in Ecuador. Along with it occur occasional specimens that tend toward the Peruvian race *malia* Godman.

I have not examined the male genitalia of *venosa* and it may prove to be another race or form of *acraeida* thus reducing this group to a single species.

### 11. *L. acraeida* Butler

(Fig. 1615, Pl. II)

1868, Catalogue of the Satyridae, British Museum, p. 171, pl. 4, f. 6.

Type locality: Bolivia.

Range: Bolivia to Ecuador.

Ecuador: Hda. San Francisco, Tungurahua, 1300 m., Sept. 20-28, 1938, 9 males (F. M. B.). Rio Mapoto, Tungurahua, 1200 m., Jan. 30, 1939, one male (W. C.-M.). Hda. Sta. Ines, Tungurahua, 1200 m., Mar. 22, 1939, one male (F. M. B.). Rio Topo, Napo-Pastaza, 1226 m., July 15, 1936, 5 males (W. C.-M.); Sept. 30, 1938, 3 males (F. M. B.); Dec. 1, 1938, 1 male (F. M. B.); Dec. 17, 1938, 3 males (F. M. B.). Hda. La Palmera, Tungurahua, "1000 m.," Dec. 11, 1938, 1 male (W. C.-M.). Bet. Rio Abonica and Macas, Santiago-Zamora, 1100 m., Jan. 21, 1939, 2 males (F. M. B.).

The altitude given above for Hda. La Palmera is about 200 m. too low. The station is above the junction of the Rio Topo with the Rio Pastaza on the south side of the larger stream. The elevation of the junction is close to 1200 m. The region where this species abounds lies in the lower part of the humid subtropical forest in the foothills. My series of specimens show many indications of the reddish brown spots on the margins of the hindwings, in no case, however, are the spots well defined or is there a complete series of them such as is found on the race *malia* Godman from Peru.

Roeber erected the genus *Trophonina* for this species. The superficial aspects are quite striking but that is insufficient for separating it from *Lymanopoda*. The venation at the end of the cell of the forewing does not differ from the usual type found among the brown species in the genus and figured (1670 a). The male genitalia are easily recognized but are basically like those of the other species of the genus. The long distal process is straight and strongly toothed along the dorsal margin. The dorsal process is short and finely toothed. The aedaeagus is toothed on the dorso-distal region. The sub-scapium is less strongly chitinized than in the preceding species but is more lightly than in the typical species like *samius* and *ionius*. The saccus is proportionately a little longer than usual. The uncus is simple.

I wish to express my thanks to Mr. William P. Comstock of the American Museum of Natural History, Dr. William D. Field of the U. S. National Museum, J. W. Cadbury, 3rd, of the Academy of Natural Sciences, Philadelphia, and Dr. A. A. Avinoff of the Carnegie Museum, for lending me materials in their care. Dr. Field also dissected *L. shefteli* Dyar for me and sent me drawings of these organs from which I drew the figure used.

## NEW SPECIES OF CRANE-FLIES FROM SOUTH AMERICA PART X.<sup>1</sup> (Tipulidae: Diptera)

CHARLES P. ALEXANDER,  
Amherst, Massachusetts

In the present paper I wish to discuss a series of unusually interesting crane-flies that were taken at Abitagua, Oriente, Ecuador, by Mr. William Clarke-MacIntyre and his assistants of the Velastegui family, especially Miss Rosario Velastegui. Since Mount Abitagua has been mentioned frequently in the past and is certain to be of considerable importance in the future, it seems advisable to supply a few facts of interest to entomologists.

Richard Spruce (Notes of a Botanist on the Amazon and Andes; 1908) thrice mentions Abitagua. His account of the mountain as he found it on the occasion of his memorable trip in 1857 is as follows:

"The cryptogamic vegetation of some parts of the Montaña of Canelos is wonderful. There is one mountain, called Abitagua, which though not more perhaps than 5,000 feet high, is continually enveloped in mists and rains. The trees on it, even to the topmost leaves, are so thickly encased in mosses that a recognizable specimen of them would be scarcely procurable, if indeed they ever flower, which must be very rarely."—Spruce, 2: 177.

"Perhaps never a day passes without rain on this mountain, and its summit is nearly always enveloped in mist, which looks as if it were permanently hung up in the trees. The trunks and branches of the latter, and often even the uppermost leaves, are densely enveloped in mosses. Various species of *Plagiochila*, *Mastigobryum*, *Phyllogonium*, *Bryopteris*, etc., hang from the branches to the length of one to three feet, and in such thick bunches that when saturated with rain they often break off even green branches by their weight. I have been told by the cargueros of Baños that when they pass with cargoes through the most mossy parts of the Montaña after much rain has fallen they step with constant dread of being crushed by some ruptured branch."—Spruce, 2: 147.

In recent years, Mount Abitagua has been purchased by Mr. MacIntyre and the most desirable portions of the area belong to him. The following further brief account is of interest. "I think that the reason why material from Abitagua is so ample and diverse is on account of the fact that it lies in a hollow, in a cove of the Pastaza, one-half mile to the west and one-half mile to the east; the altitude is around 1,200 meters. Right here at my house it is only 1,050 and down on the beach of the river only 1,000 meters. My house is on a bench of land; directly in front of me, to the north, the hills rise gradually to nearly 2,000 meters and in back of the house it is a 50-meter climb down to

<sup>1</sup>Contribution from the Entomological Laboratory, Massachusetts State College. The preceding part under this general title was published in the *Annals of the Entomological Society of America*, 34: 231-254, 1941.

the river. Sometimes I collect in the banana groves, sometimes on a path through the woods up the hills, sometimes down along the river. Sometimes I climb up the course of one of the small mountain creeks,—there are six of them on my property,—viz., the Bella Vista, La Industria, The Fox, La Guillermina, La Eloisa, and El Eugaño. When next I collect Tipulidae I will label them carefully as to exact location and will send on a sketch map.”—MacIntyre, *in litt.*, 1940.

The types of the novelties described herewith are preserved in my extensive collection of these flies.

### **Tanypremna** Osten Sacken

#### **Tanypremna (Pehlkea) regulus** sp. n.

General coloration of notum dark brown, the praescutum with indications of more reddish stripes; pleura yellow with a narrow black transverse girdle; femora and tibiae black, the latter with a narrow white ring at base; tarsi white; wings yellowish cream color, very heavily patterned with brown; male hypopygium with the tergal lobes obtusely rounded; outer dististyle strongly narrowed outwardly; inner dististyle with a conspicuous quadrate lobe on inner basal portion, the long slender rostrum shallowly emarginate at apex.

*Male*.—Length about 22 mm.; wing, 17 mm.

*Female*.—Length, about 24 mm.; wing, 16.5 mm.

Frontal prolongation of head very short, yellow, with a long conspicuous blackened nasus, the apex of prolongation surrounding base of nasus strongly darkened; mouthparts black; palpi dark brown to black. Antennae short; scape yellow; pedicel brown; flagellum black. Front and anterior vertex light yellow, the posterior vertex and occiput abruptly dark brown; anterior vertex relatively wide, of about equal width in both sexes, approximately four times the diameter of the scape.

Pronotum testaceous yellow. Mesonotum almost uniformly dark brown, the praescutum behind with indications of more reddish brown stripes; centers of scutal lobes similarly reddened. Pleura yellow with a conspicuous black transverse girdle, extending from before the suture across the dorsopleural region, including the entire posterior half of mesepisternum, somewhat paler on the cephalic portion of the anepisternum and sternopleurite, the girdle further involving the mid-coxae. Halteres elongate, greenish yellow, knobs weakly darkened. Legs with the coxae yellow; trochanters greenish yellow; femora black, slightly paler on basal portion; tibiae black with a narrow but distinct greenish white basal ring; tarsi uniformly white. Wings with the ground color of disk yellowish cream, very heavily patterned with brown, including a postarcular area; a major darkening centering at the supernumerary crossvein in cell *M*, extending from veins *R* to *Cu*; cord and outer end of cell *1st M*<sub>2</sub> very extensively clouded, forming an almost unbroken area centering around the anterior cord and cell *1st M*<sub>2</sub>; stigma small, darker brown, confluent with the major dark area at cord; wing-margin very broadly darkened, most widely so in the anal field where these cells are almost

uniformly clouded; cells *C* and *Sc* uniformly paler brown; veins brown. Venation: Crossvein *r-m* present or obliterated by fusion of veins *R*<sub>4+5</sub> and *M*<sub>1+2</sub>; a supernumerary crossvein in cell *M*, as in the subgenus.

Abdomen of male obscure yellow, the tergites with conspicuous brown lateral borders; sternites yellow, feebly darkened at the incisures; hypopygium large, somewhat darker, yellowish brown. In female, tergites brown, sternites yellow, the caudal borders of the segments narrowly dark brown. Ovipositor with long slender cerci. Male hypopygium with the lobes of tergite obtusely rounded. Outer dististyle broad at base, narrowed to a tapering apical lobe. Inner dististyle with a basal flange bearing a series of more than twenty short blackened spines arranged in a more or less evident double row; apex of style produced into a slender rostrum that is shallowly emarginate at apex; inner basal portion of style produced into a broad quadrate lobe.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, April 4, 1940 (MacIntyre). *Allotopotype*, ♀, Abitagua, Cunibunda, altitude 1,100 meters, April 2, 1940.

The nearest relative is *Tanypremna* (*Pehlkea*) *pallitarsis* Alexander, which differs conspicuously in the restricted dark wing pattern and the very distinct structure of the male hypopygium.

***Tanypremna* (*Tanypremnella*) *megacera* sp. n.**

General coloration orange; antennae 10-segmented, elongate in male, the organ being approximately two-thirds the length of the body; flagellar segments with very long erect pubescence; halteres black, the base of stem yellow; legs black the femoral bases restrictedly brightened; wings whitish hyaline, stigma dark brown, conspicuous; abdominal tergites obscure orange, the posterior margins of the segments darkened; eighth segment uniformly blackened.

*Male*.—Length about 11–13 mm.; wing, 12–13.2 mm.; antenna, about 8–9 mm.

*Female*.—Length, about 9 mm.; wing, 11 mm.; antenna, about 1.5 mm.

Frontal prolongation of head yellow, relatively short; nasus distinct, black; palpi black. Antennae 10-segmented; in male elongate, approximately two-thirds the length of body; scape and pedicel brown, flagellum black; flagellar segments long-cylindrical, with long conspicuous erect black setae; antennae of female short, with fewer conspicuous verticils and no erect pubescence. Head orange; vertical tubercle low.

Mesonotum almost uniformly orange, the praescutal stripes and centers of scutal lobes vaguely more yellow, poorly delimited; vestiture of mesonotum very sparse and tiny. Pleura orange-yellow, unmarked. Halteres black, the base of stem yellow. Legs with the coxae and trochanters orange-yellow; femora black, the bases restrictedly obscure yellow; tibiae black; tarsi brownish black. Wings whitish hyaline; stigma oval, dark brown, conspicuous; veins dark brown to brownish black. Venation: *Rs* gently arcuated,

about two-thirds  $R_{2+3}$ ; free tip of  $Sc_2$  and  $R_2$  in transverse alignment, with no trace of  $R_{1+2}$ ; petiole of cell  $M_1$  varying from a little less than one-third to nearly one-half the cell; cell 2nd  $A$  relatively wide.

Abdomen moderately elongate; tergites obscure orange, the posterior margins of the segments broadly dark brown, on the intermediate segments involving about the outer two-fifths; eighth segment and adjoining portions of segments seven and nine forming a narrow black ring; sternites yellow, the eighth sternite blackened. Male hypopygium with the caudal margin of the large tergite transverse. Inner dististyle large and compressed, with dense abundant dark setae; no flange on outer margin as in *microcera*.

*Holotype*, ♂, Abitagua, altitude 1,800 meters, April 15, 1940 (MacIntyre). Allotopotype, ♀, April 16, 1940. Paratopotypes, 5 ♂♂, April 15–16, 1940.

The only other species of the subgenus with which the present fly might be confused is *Tanypremna* (*Tanypremnella*) *microcera* sp. n., which is well-distinguished by the short antennae in the male and by the structure of the inner dististyle of the male hypopygium.

#### ***Tanypremna* (*Tanypremnella*) *microcera* sp. n.**

General coloration of thorax yellowish brown, the pleura uniformly yellow; antennae (male) very short, the flagellar segments without erect setae; femora and tibiae black, not variegated with white; wings whitish-subhyaline, cell  $Sc$  and the stigma dark brown;  $Rs$  about three-fifths  $R_{2+3}$ ; cell 2nd  $A$  relatively narrow; abdominal tergites black, the basal rings extensively obscure yellow; a subterminal black ring; male hypopygium yellow, the inner dististyle bearing a conspicuous flange or lobe on outer margin near base.

*Male*.—Length, about 11 mm.; wing, 12 mm.; antenna, not exceeding 1.5 mm.

Frontal prolongation of head light yellow; mouthparts and palpi black. Antennae with scape and pedicel brown, flagellum black; antennae short, in the unique type broken beyond the fifth segment; first flagellar segment about equal in length to the combined scape and pedicel; second segment about two-thirds the first; third segment shorter than the second; from these proportions it is evident that the remaining segments of the organ would not be longer than the above measurements and the structure is unusually short for a member of this subgenus; flagellar segments generally cylindrical, with delicate and inconspicuous vestiture. Head orange; anterior vertex wide.

Thorax uniformly yellowish brown or light castaneous, the praescutal stripes barely differentiated from the ground, the four stripes narrowly bordered by a slightly darker brown margin; posterior sclerites of notum more infuscated. Pleura yellow, unmarked. Halteres elongate, black, the extreme base of stem yellow. Legs with the coxae and trochanters yellow; remainder of legs black, the terminal tarsal segments broken; no white on either femora or tibiae.

Wings whitish subhyaline; cell *Sc* and the stigma dark brown; veins black. Venation: *Rs* about three-fifths *R*<sub>2+3</sub>; *R*<sub>2</sub> erect, close to extreme tip of *R*<sub>1</sub>; cell 1st *M*<sub>2</sub> large, its inner end pointed; cell *M*<sub>1</sub> longer than its petiole; cell 2nd *A* relatively narrow.

Abdominal tergites black, the basal rings extensively obscure yellow, the subterminal segments uniformly blackened; basal sternites more uniformly yellow; hypopygium yellow. Male hypopygium with the inner dististyle bearing a conspicuous flange or lobe on outer margin near base; face of style with about a dozen blackened spines.

*Holotype*, ♂, Abitagua, altitude 1,800 meters, April 16, 1940 (MacIntyre).

*Tanypremna* (*Tanypremnela*) *microcera* agrees with *T. (T.) megacera* sp. n. in the lack of white rings on the femora and tibiae and in the unvariegated thoracic pleura. It differs conspicuously from the other members of the subgenus in the unusually short antennae of the male sex, in this regard more nearly approaching the condition in the typical subgenus *Tanypremna* Osten Sacken.

### *Limonia* Meigen

#### *Limonia* (*Limonia*) *subreticulata* sp. n.

Allied to *reticulata*; mesonotal praescutum buffy with a complex dark brown pattern; knobs of halteres brownish black; femora obscure yellow with two very narrow dark brown rings at and just before the tip; extreme base of tibia whitened, followed by a similarly narrow black ring; wings cream-yellow with a heavy reticulated brown pattern; *Sc* long, *Sc*<sub>1</sub> extending to about opposite three-fourths the length of *Rs*; male hypopygium with the two rostral spines arising from the summit of a common elongate tubercle.

*Male*.—Length, about 6 mm.; wing, 7 mm.

Rostrum dark brown; palpi black. Antennae with the scape black, pedicel brown; first flagellar segment brownish yellow, succeeding segments black, the outer segments broken; basal flagellar segments oval. Head dark.

Mesonotal praescutum reddish or buffy brown with a sparse pruinosity, irregularly and handsomely patterned and variegated with dark brown or brownish black spots and marblings, including an interrupted series of about four median areas, the last of which is widely expanded laterad to the sides of the sclerite at the suture, leaving small areas of the pale ground behind it; scutum whitened medially, the color continued onto the scutellum; scutal lobes and lateral portions of scutellum brownish black; posterior border of scutellum extensively pale, parascutella dark; postnotum and pleurotergite dark. Pleura variegated buffy brown and black, the latter including a more or less distinct longitudinal stripe across the dorsal sclerites. Halteres with stem yellow, knob brownish black. Legs with the coxae brown, pruinose; trochanters yellow; femora obscure yellow, the extreme tip and a nearly equal subterminal ring dark brown, the two enclosing a pale ring of similar narrowness; tibiae



with extreme base whitened, immediately followed by a blackened ring of equal width; remainder of tibiae brownish yellow; tarsi broken. Wings with the ground-color cream yellow, the prearcular and costal fields deep yellow; entire wing very heavily variegated with a reticulate dark brown pattern, including all the cells except the unpatterned yellow cell *Sc*; major dark areas at one-third the length of cell *R*, at origin of *Rs*, stigma and anterior cord, and at midlength of outer radial field; cells *M* and *Cu* with the ground more or less washed with dusky; cell *C* with about fifteen dark rays; veins brown, yellow in the ground portions of the costal border. Venation: *Sc* long, *Sc*<sub>1</sub> extending to opposite three-fourths or four-fifths *Rs*, *Sc*<sub>2</sub> at its tip; *Rs* angulated and spurred at origin; *R*<sub>2+3</sub> about one-half longer than *R*<sub>2</sub>; cell 1st *M*<sub>2</sub> long, irregular in outline; basal section of *M*<sub>2</sub> long and arcuated, subequal to distal section and more than twice *m*; *m-cu* close to fork of *M*; cell 2nd *A* wide.

Abdominal tergites dark brown, the sternites paler; hypopygium chiefly darkened. Male hypopygium with the tergite transverse, the caudal margin convexly rounded, the central portion truncate or virtually so; setae of caudal border long but sparse. Basistyle with ventro-mesal lobe simple. Dorsal dististyle a strongly curved black hook, its apex a long straight spine. Ventral dististyle large and fleshy, its area much greater than that of the basistyle; rostral prolongation near apex bearing a very strong common tubercle, with both rostral spines at and immediately before its apex, the lobe subequal in length to either spine. Gonapophyses with mesal-apical lobes straight, flattened, the apex acute and slightly curved.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, July 2, 1940 (MacIntyre).

*Limonia* (*Limonia*) *subreticulata* is most similar to *L. (L.) reticulata* (Alexander) of Mexico and the Greater Antilles, differing conspicuously in the large size, coloration of the body and legs, long *Sc* and other venational details, and, especially, the structure of the male hypopygium. *L. (L.) pampoecila* Alexander, with a vast range in Tropical America, is more distantly related.

### *Limonia* (*Dicranomyia*) *perdistalis* sp. n.

General coloration of mesonotum dark brown, the very broad cephalic and lateral borders of the praescutum yellow; halteres pale yellow; wings with a creamy ground, variegated with dark brown spots; *Sc*<sub>1</sub> ending almost opposite origin of *Rs*, *Sc*<sub>2</sub> very far from its tip, at near midlength of the vein; cell 1st *M*<sub>2</sub> long, vein *M*<sub>4</sub> beyond it only about one-fourth to one-fifth its length; male hypopygium with the two spines placed close together at near midlength of the compressed rostral prolongation of the ventral dististyle.

*Male*.—Length, about 6 mm.; wing, 6.5 mm.

Rostrum and palpi black. Antennae with scape obscure yellow; pedicel brown; basal two flagellar segments obscure yellow, the outer segments passing into dark brown; flagellar segments long-oval to truncated fusiform; terminal segment about one-third longer than the penultimate; verticils relatively short and inconspicuous. Head

obscure yellow, more buffy in central portion, the posterior parts slightly infuscated; anterior vertex relatively wide, about twice the diameter of scape.

Pronotum pale, with a greenish tinge. Mesonotal praescutum with the entire anterior and lateral portions broadly yellow, the restricted disk uniformly and abruptly dark brown, occupying only about one-half the length of the sclerite; scutum similarly dark brown, including the median area, the lateral portions of the lobes abruptly pale; scutellum dark brown, the parascutella obscure yellow; mediotergite dark brown medially, paling to obscure yellow on sides. Praescutum unusually high and convex. Pleura chiefly obscure yellow, the mesepisternum weakly infuscated on central portion. Halteres pale yellow. Legs with the coxae yellow, tinted with green, the fore pair weakly darkened at base; fore trochanters infuscated, the remaining trochanters yellow; remainder of legs broken. Wings with a creamy ground, the prearcular and costal portions clearer yellow; wing-tip in outer radial field narrowly and inconspicuously infumated; conspicuous dark brown areas at arculus,  $Sc_2$ , a common area at origin of  $R_s$  and tip of  $Sc_1$ , and the short oval stigma; narrow but very conspicuous seams along cord and outer end of cell *1st M*<sub>2</sub>; small dark marginal spots at ends of all longitudinal veins, largest on *2nd A*, the one at tip of  $M_4$  continued basad and becoming confluent with the seam at outer end of cell *1st M*<sub>2</sub>; veins yellow, darkened in the infuscated portions. Venation:  $Sc_1$  ending just beyond origin of  $R_s$ ,  $Sc_2$  very far from its tip at near midlength of the vein,  $Sc_1$  thus being longer than  $R_s$ ;  $R_{4+5}$  arcuated; cell *1st M*<sub>2</sub> long, the veins beyond it unusually short, even  $M_{1+2}$  being only about two-thirds the cell while  $M_4$  is only from one-fourth to one-fifth as long as the cell and shorter than  $m$ ;  $m-cu$  close to fork of  $M$ , about one-half longer than the distal section of  $Cu_1$ ; cell *2nd A* relatively wide, the vein sinuous, strongly curved into the margin.

Abdomen obscure greenish yellow, the caudal borders of tergites five to seven narrowly infuscated; segment eight pale; hypopygium obscure brownish yellow, the basistyle darker. Male hypopygium with the tergite transverse, the caudal border gently convex laterally. Basistyle small, only a little more extensive than its simple ventromesal lobe and scarcely a fifth as large as the fleshy ventral dististyle. Dorsal dististyle a small curved yellow rod, the tip acute. Ventral dististyle with the rostral prolongation compressed-flattened, yellow, with the two spines placed close together at near midlength of the outer margin; spines slightly unequal in length, slightly flattened, blade-like. Gonapophyses with the mesal-apical lobes very short, the acute tips bent laterad. Aedeagus relatively narrow.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, June 27, 1940 (MacIntyre).

*Limonia (Dicranomyia) perdistalis* is so different from all other regional species of the subgenus that it requires no comparison with any. The conspicuous pattern of the mesonotum is somewhat as in various species of the subgenus *Rhipidia*, but the fly is a true *Dicranomyia*. The venational features of unusually long  $Sc_1$  and the very

short veins beyond cell  $1st\ M_2$  furnish very strong characters for the recognition of the fly.

***Limonia (Neolimnobia) pugilis* sp. n.**

General coloration of mesonotum black, including a praescutal discal area, the scutal lobes and the mediotergite; antennae black throughout; ventral portion of vertex velvety black; knobs of halteres blackened; legs black, the femora with the narrow tip and a subterminal ring yellow; wings yellow with a reticulated crossbanded pale brown pattern, the bands interrupted by spots of the ground color; supernumerary crossvein in cell  $R_3$  beyond midlength of cell; cell  $1st\ M_2$  subequal in length to vein  $M_{1+2}$  beyond it; abdominal tergites dark brown or brownish black, including the hypopygium; sternites obscure brownish yellow; outermost rostral spine of male hypopygium placed at extreme apex of prolongation.

*Male*.—Length, about 7 mm.; wing, 9 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments oval, the incisures well-indicated. Head with disk velvety black, more grayish on front and anterior vertex, along with inner orbits and on the occipital region; anterior vertex narrow, a little less than the diameter of scape.

Pronotum black, gray pruinose. Mesonotal praescutum with three confluent black stripes, the humeral region slightly paler and more pruinose; scutal lobes entirely black, the median region, scutellum and extreme cephalic portion of mediotergite pale; remainder of mediotergite and the parascutella blackened. Pleura and pleurotergite pale, variegated with blackened areas on anepisternum and ventral sternopleurite. Halteres with stem obscure yellow, knob blackened. Legs with fore coxae black, paler at tips; middle and hind coxae yellow; trochanters yellow; femora black, restrictedly brightened basally, the extreme tip and a slightly more extensive subterminal ring yellow, the black ring thus enclosed much wider; tibiae and tarsi black. Wings yellow, with a reticulated, crossbanded, pale brown pattern, appearing roughly as four bands that are interrupted by spots of the ground; basal dark band much broken; second band subequal in width to first, ending at origin of  $R_s$ , more nearly uninterrupted by pale areas; third band at cord, fourth at level of the supernumerary crossvein in cell  $R_3$  and crossvein  $m$ ; extreme wing-tip further darkened; stigma not darker than the remainder of the patterned areas; veins brown, not brightened in the ground areas. Venation:  $Sc_1$  ending opposite origin of  $R_s$ ; supernumerary crossvein in cell  $R_3$  beyond midlength of cell; cell  $1st\ M_2$  subequal in length to vein  $M_{1+2}$  beyond it;  $m-cu$  at fork of  $M$ .

Basal abdominal tergite obscure yellow, the posterior border darkened; remaining tergites dark brown or brownish black; sternites obscure brownish yellow; hypopygium uniformly dark brown. Male hypopygium with the tergite deeply emarginate on caudal border. Ventro-mesal lobe of basistyle relatively long. Ventral dististyle large and fleshy, the rostral prolongation unusually short; rostral spines short, the outer one placed at extreme tip of prolongation, the inner more proximad.

*Holotype*, ♂, Abitagua, Mayorga Playa, altitude 1,100 meters, April 12, 1940 (MacIntyre).

*Limonia* (*Neolimnobia*) *pugilis* is quite different from *L. (N.) diva* (Schiner) which appears to be its closest ally. It differs especially in the coloration of the body, antennae, legs and wings, and in slight details of the male hypopygium.

***Limonia* (*Geranomyia*) *assueta* sp. n.**

General coloration of thoracic notum dark plumbeous, the praescutum unpatterned; ventral pleurites yellow; halteres and legs uniformly dark; wings with the ground color weakly infuscated, heavily and distinctly patterned with brown; *Sc* long, *Sc*<sub>1</sub> ending about opposite three-fourths the length of *Rs*; male hypopygium with the rostral spines two, arising separately from very low tubercles placed near the base of the straight rostral prolongation; mesal-apical lobes of gonapophyses appearing as stout blackened horns.

*Male*.—Length, excluding rostrum, about 5 mm.; wing, 6 mm.; rostrum, about 2.3 mm.

Rostrum relatively long, black throughout, nearly one-half the length of body. Antennae black throughout, relatively short; flagellar segments oval, with short verticils; terminal segment a trifle longer than the penultimate. Head dark with indications of a narrow pale median line; eyes large; anterior vertex narrow.

Pronotum dark brown. Mesonotal praescutum uniformly dark plumbeous or grayish brown, without stripes; posterior sclerites of notum similar in color, the median region of scutum paler; notum glabrous. Pleura with ventral portions, including sternopleurite, meral region and all coxae yellow, the dorsal sclerites and pleurotergite infuscated, forming a more or less distinct dorsal stripe. Halteres infuscated. Legs with coxae yellow, as described; trochanters yellow; remainder of legs black, the femoral bases not or scarcely brightened. Wings with a weak brown tinge, heavily patterned with darker brown, the areas unusually clear and well-defined, distributed as follows: Supernumerary crossvein in cell *Sc*; origin of *Rs*; fork of *Sc*; stigma; cord and outer end of cell 1st *M*<sub>2</sub>; distal ends of all longitudinal veins, largest at *R*<sub>3</sub> and 2nd *A*, those at wing-tip small and confluent; veins dark. Venation: *Sc* long, *Sc*<sub>1</sub> ending about opposite three-fourths the length of *Rs*, *Sc*<sub>2</sub> a short distance from its tip; a supernumerary crossvein in cell *Sc*; cell 1st *M*<sub>2</sub> a little shorter than vein *M*<sub>1+2</sub> beyond it; *m-cu* close to fork of *M*.

Abdominal tergites brownish black; basal sternites obscure yellow; hypopygium black, the ventral dististyle pale. Male hypopygium with the tergite transverse, the lateral lobes low, obtusely rounded, provided with long coarse setae. Basistyle of moderate size, the ventro-mesal lobe simple. Dorsal dististyle a gently curved sclerotized blade, the tip acute. Ventral dististyle of moderate size, its area about one-half greater than that of the basistyle; rostral prolongation straight, slender, the tip narrowly obtuse; rostral spines two, placed close together near base of prolongation, arising from very low basal tubercles. Gonapophyses with mesal-apical lobes appearing as blackened stout horns, gently curved to the acute tips.

*Holotype*, ♂, Abitagua, Mayorga Playa, altitude 1,100 meters, April 12, 1940 (MacIntyre).

In its wing-pattern, *Limonia* (*Geranomyia*) *assueta* is most like *L. (G.) biargentata* Alexander and *L. (G.) separata* Alexander, but from the nature of its thoracic coloration belongs to an entirely different section of the subgenus. It is well-distinguished by the unvariegated praescutum, uniformly darkened halteres and legs, the very clearly defined wing spots, and the structure of the male hypopygium.

***Limonia* (*Geranomyia*) *nugatoria* sp. n.**

General coloration of mesonotum dark brown or brownish black, with indications of three still darker stripes on cephalic third of praescutum; dorsal pleurites darkened; wings almost uniformly and strongly infuscated, the small oval stigma darker brown; *Sc* long, *Sc*<sub>1</sub> ending beyond midlength of *Rs*; male hypopygium with the ventral dististyle large and fleshy, its area about three times the basistyle; rostral prolongation pendant, pale, with two long straight black spines arising close together from small separate tubercles; mesal-apical lobes of gonapophyses appearing as short curved horns.

*Male*.—Length, excluding rostrum, about 5 mm.; wing, 6 mm.; rostrum, about 3 mm.

Rostrum of moderate length, a little exceeding one-half the length of remainder of body, black, the tips of the labial palpi a trifle paler. Antennae black; flagellar segments oval, verticils short. Head black, with a gray dorso-median stripe.

Pronotum brown. Mesonotal praescutum dark brown, with indications of three still darker, brownish black stripes on the cephalic third, these becoming obsolete behind; posterior sclerites of notum dark brown to brownish black, the median area of scutum narrowly pale. Pleura with dorsal sclerites, including the pleurotergite, brownish black, the ventral pleurites more reddish brown, this including the sternopleurite and meral region. Halteres uniformly blackened. Legs with coxae reddish brown; trochanters obscure yellow; remainder of legs broken. Wings with an almost uniform strong brownish tinge, only the prearcular field a little paler; stigma small, oval, darker brown; veins dark brown. Venation: *Sc* long, *Sc*<sub>1</sub> ending just beyond midlength of *Rs*, *Sc*<sub>2</sub> at its tip; a supernumerary crossvein at near midlength of cell *Sc*; cell 1st *M*<sub>2</sub> subequal in length to vein *M*<sub>1+2</sub> beyond it; *m-cu* a short distance beyond fork of *M*; vein 2nd *A* strongly sinuous.

Abdominal tergites and hypopygium brownish black; basal sternites obscure yellow, passing into brownish yellow. Male hypopygium with the tergite transverse, moderately long, the caudal margin weakly emarginate. Basistyle with ventro-mesal lobe simple. Dorsal dististyle a blackened curved hook, very gradually narrowed to a long acute spinous point. Ventral dististyle elongate, its area exceeding three times that of the basistyle; rostral prolongation small, pendant, pale, the apex obliquely truncated, the ventral angle obtuse; rostral spines two, subequal, black, arising from small separate basal tubercles at base of prolongation. Gonapophyses with mesal-

apical lobes entirely blackened, appearing as short curved horns, their tips acute.

*Holotype*, ♂, Abitagua, Mayorga Playa, altitude 1,100 meters, April 12, 1940 (MacIntyre).

Other small regional species of the subgenus with almost uniformly infumated wings include *Limonia* (*Geranomyia*) *conquisita* Alexander, *L. (G.) disparilis* Alexander, *L. (G.) fluxa* Alexander and *L. (G.) microphaea* Alexander. The present fly differs from all of these in the long *Sc* and in the structure of the male hypopygium.

#### ***Limonia* (*Geranomyia*) *subpentheres* sp. n.**

General coloration brownish black, the praescutum with three blackish stripes in addition to the darkened lateral borders; rostrum relatively short; wings with a weak brownish tinge, the base more whitened; *Sc* short, *Sc*<sub>2</sub> lacking; male hypopygium with a single very long rostral spine and a subtending, much more slender seta or setoid spine, both arising from the apex of an unusually long tubercle; prolongation extended beyond the level of origin of the tubercle.

*Male*.—Length, excluding rostrum, about 5 mm.; wing, 5.3 mm.; rostrum, about 2 mm.

Rostrum black, relatively short, being a little less than one-half the length of body. Antennae black throughout, relatively short; basal flagellar segments short-oval, the outer segments more elongate; terminal segment nearly twice the length of the penultimate. Head with the anterior vertex narrow, less than one-half the diameter of scape, the eyes correspondingly large; head black, the anterior vertex and a backward extension from it more grayish.

Pronotum pale medially, dark on sides. Mesonotal praescutum with the ground color grayish, with three conspicuous blackish stripes, the median one very broad, the sublateral pair narrow; in addition to these stripes the lateral margins of the sclerite are broadly blackened; humeral region reddish brown; posterior sclerites of notum chiefly brownish black. Pleura with the dorsal sclerites, including the pleurotergite, blackened, the ventral areas paler brown. Halteres black, the extreme base of stem obscure yellow. Legs with the coxae reddish brown, the fore pair darker; trochanters brownish testaceous; remainder of legs broken. Wings with a weak brownish tinge, the prearcular field more whitened; stigma small, oval, only slightly darker than the ground; veins brown. Venation: *Sc* short, *Sc*<sub>1</sub> ending about opposite one-fifth the length of *Rs*, *Sc*<sub>2</sub> lost by atrophy; cell 1st *M*<sub>2</sub> moderately long, about equal in length to vein *M*<sub>4</sub> beyond it; *m-cu* shortly beyond fork of *M*.

Abdominal tergites, including hypopygium, dark brown; basal sternites paler. Male hypopygium with the lateral tergal lobes conspicuous, obtusely rounded, with long conspicuous black setae that continue along the lateral borders to the base of sclerite. Basistyle relatively small; ventro-mesal lobe simple. Dorsal dististyle a small, gently curved rod, the tip acute. Ventral dististyle large and fleshy, its total area about three times that of basistyle; rostral prolongation glabrous, basad of the tubercle stout, beyond this point

abruptly narrowed into a slender lobe that is nearly equal in length to the basal tubercle of the rostral spines; only a single well-developed rostral spine, this very long, slender, curved, its length greater than the dorsal dististyle; spine arising from an unusually long basal tubercle that is about one-half the length of spine; in addition to the major spine there is a strong seta or setoid spine likewise arising from the apex of the tubercle, subequal in length to the major rostral spine but very slender; despite its setoid nature, this might be considered as representing a second rostral spine. Gonapophyses with mesal-apical lobe slender, pale throughout.

*Holotype*, ♂, Abitagua, Mayorga Playa, altitude 1,100 meters, April 12, 1940 (MacIntyre).

*Limonia* (*Geranomyia*) *subpentheres* is most similar to the Mexican *L. (G.) peniheres* Alexander and *L. (G.) neopentheres* Alexander, differing conspicuously from both in the short *Sc* and in the structure of the male hypopygium.

***Limonia* (*Geranomyia*) *hirsutinota* sp. n.**

General coloration of mesonotum obscure brownish yellow, the praescutum with three conspicuous brown stripes in addition to the darkened lateral borders; praescutum and scutum with abundant, long and conspicuous, erect black setae; femora obscure yellow, the apices broadly yellow, enclosing a narrow brown subterminal ring; wings with cells of basal half infuscated, deepest in the anal cells, the outer cells and costal border pale yellow; stigma and narrow seams along cord and outer end of cell 1st *M*<sub>2</sub> darkened; *Sc* long; abdominal tergites dark brown; male hypopygium with the rostral prolongation of ventral dististyle unusually short and stout, bearing two long spines from a low common sclerotized base.

*Male*.—Length, excluding rostrum, about 6–7 mm.; wing, 6.8–8 mm.; rostrum, about 4.5–4.8 mm.

—Rostrum elongate, black, the tips of the labial palpi slightly paler. Antennae black throughout, somewhat longer than usual in the subgenus; flagellar segments cylindrical, a little shorter than their longest verticils, the longest of which are unilaterally arranged; terminal segment about one-third longer than the penultimate. Head with the anterior vertex gray, the posterior vertex more blackened.

Pronotum light brown above, darker on sides. Mesonotal praescutum obscure yellow or brownish yellow, with three conspicuous brown stripes, the median one a little darker in color than the sublaterals, narrowed behind and reaching the suture; lateral margins of praescutum pale brown; scutum buffy, the narrow midline still paler, the scutal lobes with their mesal edges narrowly bordered by darker, being a direct prolongation of the sublateral praescutal stripe; scutellum weakly infuscated, with the central line pale, the parascutella slightly darker; postnotum brown; praescutum and scutum with abundant long and conspicuous erect setae occupying the sublateral dark stripes and the outer pale interspaces. Pleura pale brown on dorsal portions, the ventral areas yellow. Halteres

with stem yellow, knob brownish black. Legs with the coxae and trochanters pale yellow, the fore coxae a trifle darker; femora obscure yellow to brownish yellow, the apex broadly yellow, enclosing a conspicuous brown subterminal ring; tibiae pale brown, the distal end and the tarsi even paler. Wings with about the proximal half weakly infuscated, becoming more intense in the Anal cells, the prearcular and costal fields remaining pale yellow; distal portion of wing pale yellow, the stigma and narrow seams at fork of *Sc*, along cord and outer end of cell 1st  $M_2$  pale brown; veins brown, *Sc* more yellow. Costal fringe (male) erect and conspicuous on basal third of wing, outwardly becoming more appressed and inconspicuous. Venation:  $Sc_1$  ending about opposite two-thirds the length of *Rs*,  $Sc_2$  near its tip; a supernumerary crossvein in cell *Sc* at near three-fifths the length; *Rs* angulated at origin; cell 1st  $M_2$  about equal in length to vein  $M_{1+2}$  beyond it; *m-cu* at fork of *M*; vein 2nd *A* nearly straight.

Abdominal tergites dark brown, sternites obscure yellow; hypopygium dark. Male hypopygium with the tergite transverse, the low lobes provided with abundant conspicuous setae. Basistyle relatively small, the ventro-mesal lobe relatively long and slender but simple. Dorsal dististyle a gently curved rod, the apex abruptly narrowed into a spine. Ventral dististyle large and fleshy, its total area exceeding twice that of the basistyle; rostral prolongation short and stout, the two rostral spines placed at near midlength on outer margin; spines very long, exceeding the prolongation in length, arising from a very low common base but placed one immediately distad of the other so the base is elongate; spines slightly unequal in length; apex of prolongation obliquely truncate, its lower ventral angle a short point. Gonapophyses with mesal-apical lobe blackened, narrowed to the small, slightly decurved, blackened point.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, March 21, 1940 (MacIntyre). *Paratopotype*, ♂, April 15, 1940.

From all other members of the subgenus having a somewhat similar praescutal pattern, including a host of species in Tropical America, the present fly differs conspicuously in the pattern of the wings, the conspicuous erect setae on the mesonotum, and the details of structure of the male hypopygium, especially the ventral dististyle and its rostral prolongation. The nature of the thoracic setae is somewhat as in the otherwise very different *Limonia* (*Geranomyia*) *deliciosa* Alexander.

### ***Limonia* (*Rhipidia*) *polyclada* sp. n.**

General coloration of mesonotum dark brown, the lateral borders very broadly and abruptly yellow; antennae with eleven branched segments, flagellar segments two to eleven, inclusive, each with two long branches, the terminal segment with a conspicuous basal branch and an additional small tubercle; thoracic pleura dark brown; legs yellow; wings yellow, with a restricted but conspicuous dark brown pattern; inner ends of cells  $R_3$  and 1st  $M_2$  lying far proximad of cell  $R_5$ ; cell 2nd *A* wide; abdomen brownish yellow; hypopygium with the rostral



prolongation long, bearing two elongate spines at near two-thirds the length, these spines placed close together on small individual tubercles.

*Male*.—Length, about 6.5 mm.; wing, 7.6 mm.; antenna, about 2 mm.

Rostrum and palpi reduced, brown. Antennae of moderate length, pale yellow, the basal enlargements of the flagellar segments and the branches pale brown or brownish yellow; scape with ventral face dark brown; first flagellar segment strongly produced but not branched; flagellar segments two to eleven, inclusive, each with two very long branches, those of segment two only a little shorter than the longest branches of the intermediate segments, being nearly three times the length of segment; longest branch slightly exceeding three times the segment; flagellar segment eleven with branches about equal to one and one-half times the segment; terminal segment very long, irregularly branched, the basal branch longest, about one-half the total length of segment; at near midlength of this segment a small lobe or tubercle representing a rudimentary second branch; flagellar segments in addition to the elongate black verticils of the basal enlargements have abundant delicate pale setae on the branches. Head light cinnamon brown.

Pronotum and very broad margins of the praescutum, scutum, scutellum and postnotum abruptly yellow, the remainder of the disk uniformly dark brown; on praescutum, the yellow border includes the cephalic half of the sclerite; on the postnotal mediotergite all but a darkened triangle on cephalic portion; parascutella and pleurotergite yellow. Pleura abruptly dark brown, this including all but the dorsopleural region. Halteres yellow, the knobs very weakly darkened. Legs with the coxae dark brown; trochanters yellow; remainder of legs yellow, the terminal three tarsal segments abruptly blackened. Wings yellow, the costal border more saturated; a restricted but conspicuous dark brown pattern, including spots and seams at origin of *Rs*, fork of *Sc*, stigma, along cord and outer end of cell *1st M*<sub>2</sub> and a major area in cell *1st A* at bend of vein *2nd A*, this latter enclosing a small spur of a veinlet; a marginal series of brown spots on all longitudinal veins from *R*<sub>3</sub> to *2nd A* inclusive, that on *R*<sub>3</sub> largest, the others subequal in size to one another, that on *2nd A* entirely disconnected from the larger subterminal darkening above described; veins yellow, dark brown in the infuscated portions. Venation: *Sc* long, *Sc*<sub>1</sub> ending about opposite two-thirds the length of *Rs*, *Sc*<sub>2</sub> at its tip; *Rs* strongly arcuated at origin; free tip of *Sc*<sub>2</sub> and *R*<sub>2</sub> in transverse alignment; inner ends of cells *R*<sub>3</sub> and *1st M*<sub>2</sub> lying far proximad of cell *R*<sub>4</sub>; cell *1st M*<sub>2</sub> relatively long, nearly equal in total length to vein *M*<sub>1+2</sub> beyond it; *m-cu* at or shortly before fork of *M*, shorter than distal section of *Cu*<sub>1</sub>; cell *2nd A* wide.

Abdomen obscure yellow or brownish yellow; hypopygium uniformly yellow. Male hypopygium with the tergite transverse, the lobes very low. Ventro-mesal lobe of basistyle with a small lateral lobule on its face. Dorsal dististyle a long conspicuous darkened rod, the acute slender tip decurved. Ventral dististyle relatively small, with a long conspicuous rostral prolongation, the two long,

gently curved spines placed close together at near two-thirds the length of the prolongation, arising from small individual tubercles. Gonapophyses with mesal-apical lobes long and straight, darkened, the tips suddenly narrowed.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, June 27, 1940 (MacIntyre).

*Limonia* (*Rhipidia*) *polyclada* is very distinct from all described species of the subgenus. The branched terminal segment of the antenna is an almost unique character that separates the species from all others in the Neotropical fauna. The peculiar thoracic pattern is somewhat as found in other species of *Rhipidia*, as *L. (R.) annulicornis* (Enderlein) and *L. (R.) subpectinata* (Williston), as well as in species of other allied subgenera, including *L. (Dicranomyia) perdistalis* sp. n. The only other described species of *Rhipidia* having pectinations on the terminal flagellar segment is *L. (R.) antennata* (Brunetti) of the western Himalayas (see Alexander, Philippine Journ. Sci., 56: 549-550; 1935).

***Limonia* (*Rhipidia*) *sprucei* sp. n.**

General coloration of notum brown, the lateral praescutal borders broadly yellow; pleura yellow with a conspicuous black longitudinal stripe; antennae (male) with eight flagellar segments that are provided with two long slender branches each; antennae black throughout, including the flagellar pedicels; halteres and legs black; wings with a strong blackish tinge, almost unpatterned; abdominal tergites brownish black, basal sternites yellow with blackened caudal borders; male hypopygium with the ventro-mesal lobe of basistyle bearing a small accessory lobule; rostral prolongation long and slender, with two relatively short spines placed on the face of prolongation just beyond midlength.

*Male*.—Length, about 5 mm.; wing, 5.5 mm.; antenna, about 2.4 mm.

Rostrum and palpi black. Antennae (male) black throughout, including the apical pedicels of all flagellar segments; first flagellar segment merely produced; flagellar segments two to nine, inclusive, each with two very long branches; segment ten with a single long branch that exceeds the segment in length; segment eleven with the basal enlargement simple; longest branches nearly three times the segments, clothed with abundant delicate setulae. Head dark brown, sparsely pruinose; eyes very large, almost contiguous, reducing the anterior vertex to a linear strip.

Pronotum black. Mesonotal praescutum reddish brown, the lateral margins broadly yellow; posterior sclerites of notum brown, the median area of scutum narrowly paler. Pleura and pleurotergite yellow, with a relatively narrow but very conspicuous longitudinal black stripe extending from the pronotum to the base of abdomen, passing beneath the halteres. Halteres blackened, the extreme base of stem yellow. Legs with the coxae and trochanters yellow; remainder of legs uniformly black. Wings with a strong blackish tinge, almost unvariegated except by the slightly darker oval stigma; cord and outer end of cell 1st *M*<sub>2</sub> very narrowly and

vaguely seamed with darker; veins and trichia dark brown. Macrotrichia of veins long and conspicuous. Venation:  $Sc$  long,  $Sc_1$  ending about opposite three-fourths  $Rs$ ,  $Sc_2$  at its tip;  $Rs$  weakly angulated at origin; vein  $R_3$  decurved at outer end; cell 1st  $M_2$  shorter than vein  $M_4$  beyond it;  $m-cu$  a short distance beyond fork of  $M$ .

Abdominal tergites, including hypopygium, brownish black; basal sternites yellow, the caudal borders darkened. Male hypopygium with the tergite transverse, narrowed outwardly, the caudal margin very gently emarginate. Basistyle with the ventro-mesal lobe obtuse, with a small secondary lobule on the cephalic face. Dorsal dististyle a gently curved rod, the apex suddenly narrowed into a spine. Ventral dististyle of moderate size, its total area slightly greater than that of basistyle; rostral prolongation long and slender; rostral spines two, placed close together on face of style just beyond midlength, arising from small separate tubercles; spines subequal in length; on opposite face of prolongation from the spines with two very strong spinous setae. Gonapophyses with mesal-apical lobes stout, nearly straight, the tips gently expanded and weakly apiculate.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, March 22, 1940 (MacIntyre).

It is particularly fitting that a species from Abitagua be dedicated to the great botanist and student of the Bryophytes, Richard Spruce. The fly is readily told from other species with eight long-bipectinate flagellar segments by the coloration of the thorax and legs, and especially by the almost uniformly blackened wings. It is most similar to species such as *Limonia (Rhipidia) costalis* (Williston) and *L. (R.) variicosta* Alexander.

## Orimarga Osten Sacken

### *Orimarga (Orimarga) saturnina* sp. n.

Allied to *funerula*; general coloration black, the thoracic pleura with a conspicuous silvery longitudinal stripe; legs black throughout; wings with a strong blackish suffusion;  $R_{1+2}$  elongate; cell  $M_2$  longer than its petiole;  $m-cu$  about opposite midlength of  $Rs$ ; male hypopygium with the dististyles unusually short, especially the nearly straight outer style; setae of mesal face of basistyle simple.

*Male*.—Length, about 6.5–7 mm.; wing, 5.5–6 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments oval, with very short glabrous apical pedicels; terminal segment short-oval, only about one-third the penultimate; verticils short. Head light gray or silvery gray in front, darker gray behind.

Pronotum silvery gray pruinose. Mesonotum black, the surface dull to rather strongly polished. Pleura black, with a broad silvery longitudinal stripe extending from behind the fore coxae to above the hind coxae, narrowed posteriorly. Halteres with stem dusky, knob darkened. Legs black throughout. Wings with a strong blackish suffusion, somewhat stronger on anterior half; restricted whitish streaks in posterior prearcular field, distal end of cell  $R_5$  and as narrow borders to vein  $M$  in cell  $R$ , and veins  $M_{1+2}$ ,  $M_{3+4}$  and  $M_4$ ;

veins brown. Costal fringe relatively short but dense. Venation: *Sc* long, *Sc*<sub>1</sub> ending about opposite one-third to two-fifths the length of *Rs*, *Sc*<sub>2</sub> at its extreme tip, just before midlength of *Rs*; free tip of *Sc*<sub>2</sub> distinct; distal section of *R*<sub>1</sub> a little more than one-half the long *R*<sub>1+2</sub>; cell *M*<sub>2</sub> much longer than its petiole; *m-cu* about opposite midlength of *Rs*; cell 2nd *A* relatively wide, especially at base.

Abdomen elongate, black throughout. Male hypopygium with the dististyles unusually short, especially the nearly straight outer style; inner dististyle a trifle longer, weakly dilated outwardly, with short inconspicuous setae only; a small oval lobe with long setae at junction of the two dististyles. Setae on mesal face of basistyle moderately long and conspicuous but simple. Phallosome with the apical lobe of inner pair of apophyses unusually long and narrow, the oblique apex microscopically serrulate or roughened, the degree varying in different specimens; outer apophyses narrowed to acute tips.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, March 18, 1940 (MacIntyre). *Paratopotypes*, 13♂♂, on five pins, one also including the holotype specimen.

*Orimarga (Orimarga) saturnina* is generally similar to other black-winged members of the subgenus having uniformly blackened tarsi and elongate vein *R*<sub>1+2</sub>, including *O. (O.) funerula* Alexander, *O. (O.) lanei* Alexander, and *O. (O.) scabriseta* Alexander. It differs conspicuously in the details of venation and, especially, in the very different structure of the male hypopygium.

#### *Orimarga (Orimarga) chionopus* sp. n.

Allied to *niveitarsis*; general coloration polished black, the lateral margin of mesonotum and the ventral pleura each with a narrow silvery longitudinal stripe; legs black, the tarsi abruptly white, including the tips of the basitarsi; wings narrow, the prearcular region petiolate, disk strongly suffused with blackish; costal fringe long in both sexes; *Sc* short, *Sc*<sub>1</sub> ending some distance before origin of *Rs*; *R*<sub>1+2</sub> subequal to or nearly twice as long as *R*<sub>2</sub>; *m-cu* opposite origin of *Rs*; cell 2nd *A* narrow; male hypopygium with the dististyle trilobed; phallosome complex.

*Male*.—Length, about 6.5 mm.; wing, 5.8 mm.

*Female*.—Length, about 7–9 mm.; wing, 5.2–6 mm.

Rostrum and palpi black. Antennae black, the scape more pruinose; antennae 15-segmented; flagellar segments oval, constricted at the incisures, with very short glabrous apical pedicels; terminal segment one-half longer than the penultimate; verticils exceeding the segments in length. Head black, sparsely pruinose, the front more silvery.

Thorax polished black, with two narrow silvery longitudinal stripes, the more dorsal including the lateral border of the praescutum and scutum; second stripe on pleura, occupying the dorsal sternopleurite, behind traversing the meron. Halteres elongate, black. Legs with the coxae brownish black; trochanters testaceous yellow, the fore pair brown; femora brownish black, the bases restrictedly pale; tibiae black; basitarsi black, the distal third whitened; suc-

ceeding segments white, the outer two again darkened. Wings narrow, strongly petiolate at base; disk strongly suffused with blackish, somewhat more saturated in the costal portion and along vein *Cu*; prearcular field more whitened; veins of outer medial field narrowly bordered by pale; veins dark brown. Costal fringe long and conspicuous in both sexes. Venation: *Sc* short, *Sc*<sub>1</sub> ending a distance before origin of *Rs* about equal to vein *R*<sub>1+2</sub>; *Rs* long, angulated at origin; *R*<sub>1+2</sub> a little shorter than *R*<sub>2+3</sub>, subequal to or nearly twice *R*<sub>2</sub> alone; *r-m* a little proximad of level of *R*<sub>2</sub>; petiole of cell *M*<sub>3</sub> about equal to or slightly shorter than the cell; *m-cu* opposite origin of *Rs*; cell 2nd *A* relatively short and narrow; vein 2nd *A* pale, gently arcuated, without trichia.

Abdomen, including hypopygium, black. Male hypopygium with the dististyle trilobed, the outer arm a slender glabrous rod, the inner arm nearly as long, bearing a few very long setae at its apex and another single seta on face near base; intermediate arm broad-based, the distal third narrowed into a slender spinous point; surface of style basad of lobes with several long scattered setae. Basistyle with normal strong setae. Phallosome complex; aedeagus elongate, deeply bifid at tip; gonapophyses produced into two spinous points, the outermost longer and stronger, and a pale capitate structure covered with numerous pale setae.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, March 21, 1940 (MacIntyre). *Allotopotype*, ♀. *Paratopotype*, ♀, Cunibunda, Abitagua, March 22, 1940.

The nearest relative of the present fly is *Orimarga* (*Orimarga*) *niveitarsis* Alexander, and its more northern race, *majuscula* Alexander, of Middle America. Both species have the tarsi abruptly snowy white and vein *Sc* unusually short. The present fly is well-distinguished by the blackened wings and by the details of venation. Unfortunately the male hypopygium of *niveitarsis* has not been described but will unquestionably provide further specific characters when made known.

### *Limnophila* Macquart

#### *Limnophila pergracilis* sp. n.

General coloration dark brown, the thorax without distinct stripes; antennae (male) very long, almost equalling the body in length, the flagellar segments with conspicuous outspreading verticils; legs dark brown; wings whitish, heavily patterned with brown; *Sc* long; *R*<sub>2</sub> and *R*<sub>1+2</sub> subequal; cell *M*<sub>1</sub> shorter than its petiole; abdominal tergites brownish black, sternites weakly bicolored, yellow, the bases broadly brownish black; male hypopygium with the apex of outer dististyle terminating in a simple spine; inner dististyle with a setiferous tubercle on outer margin shortly before apex.

*Male*.—Length, about 6.5–7 mm.; wing, 6.5–7 mm.; antenna, about 6.3–6.5 mm.

Rostrum short, black; palpi black. Antennae (male) very long and slender, almost as long as the entire body; scape black, pedicel and flagellum lighter colored, the extreme bases of the flagellar

segments a trifle paler; flagellar segments elongate-cylindrical, with long, conspicuous, outspreading verticils. Head dark brown; anterior vertex narrow, a little less than the diameter of scape; eyes large; vertex with coarse black setae.

Pronotum dark brown. Mesonotum almost uniform dark brown, without distinct stripes, the surface glabrous. Pleura dark brown, the sternopleurite a little brightened. Halteres relatively long and slender, infuscated, the base of stem paler. Legs with coxae and trochanters brownish testaceous; remainder of legs dark brown; tibial spurs present; claws simple. Wings with the ground color whitish, heavily patterned with brown, the dark color in the type specimen subequal in total amount to the ground, in the paratype the dark markings somewhat more restricted, being smaller than the ground interspaces; dark areas including major markings before arculus; beyond arculus, extending from *C* to *M*; a conspicuous area at origin of *Rs*, extending to *C*; extensive seams across cord and outer end of cell 1st *M*<sub>2</sub>; cells beyond cord heavily variegated by dark spots; major clouds at ends of veins 1st *A* and 2nd *A*; axilla narrowly darkened; cells *C* and *Sc* slightly more yellowish in the ground areas; veins yellow, darker in the clouded portions. Venation: Anterior arculus present; *Sc* long, *Sc*<sub>1</sub> ending beyond fork of *R*<sub>2+3+4</sub>, *Sc*<sub>2</sub> at its tip; *Rs* long, in alignment with *R*<sub>2+3+4</sub>; *R*<sub>2</sub> and *R*<sub>1+2</sub> subequal; cell *M*<sub>1</sub> shorter than its petiole; cell 1st *M*<sub>2</sub> elongate, rectangular; *m-cu* about two-thirds its length beyond fork of *M*; cell 2nd *A* wide.

Abdominal tergites brownish black, the sternites weakly bicolored, obscure yellow, with the basal third brownish black; hypopygium brownish black. Male hypopygium with the outer dististyle a straight blackened rod, the outer apical angle terminating in a single acute spine, the usual second spine or point atrophied or virtually so. Inner dististyle narrowed at apex, with a small setiferous tubercle on outer margin shortly before apex. Gonapophyses with the spinous points very unequal, the inner one very small.

*Holotype*, ♂, Abitagua, Cunibunda, altitude 1,100 meters, April 8, 1940 (MacIntyre). *Paratopotype*, ♂, Abitagua, June 27, 1940.

*Limnophila pergracilis* is closest to *L. nematocera* Alexander, likewise from Abitagua. It differs conspicuously in the coloration, in the great reduction of dark color in the wing pattern, and in the structure of the male hypopygium, especially of the outer dististyle. I had formerly placed *nematocera* in the genus *Austrolimnophila* since the anterior arculus in the type specimen is very faint to obsolete, much less indicated than in the present fly. Both flies are obviously congeneric and until more information concerning them becomes available it appears best to place them in *Limnophila*.

### **Elephantomyia** Osten Sacken

#### **Elephantomyia primitiva** sp. n.

General coloration brownish black; rostrum, halteres and legs brownish black; eyes of male large, the anterior vertex much reduced; wings brownish yellow, heavily patterned with darker brown, including

a broad subbasal band; cell 1st  $M_2$  small; male hypopygium with the aedeagus simple, broad at base, the short apex slender, straight.

*Male*.—Length, excluding rostrum, about 5.5–6.5 mm.; wing, 6.5–7.5 mm.

Rostrum black, relatively long, the apex apparently broken in the specimens available, in the longest of these the beak about equal in length to the head and most of thorax combined. Antennae 15-segmented; dark throughout; flagellar segments cylindrical, decreasing in size outwardly, the terminal segment pointed at apex; verticils of outer segments about twice as long as the basal ones but still not very conspicuous. Eyes large, the anterior vertex at narrowest point greatly reduced, only about one-fourth to one-fifth the diameter of scape; head brown, the anterior vertex gray.

Pronotum dark brown. Mesonotum brown, the median region of praescutum even darker, brownish black; posterior sclerites blackened, the parascutella a little paler. Pleura brownish black. Halteres brownish black, the base of stem paler. Legs brownish black, the femoral bases a trifle brightened; setae of legs simple (thus excluding *Toxorhina-Ceratocheilus*). Wings with the restricted ground brownish yellow, heavily patterned with darker brown, as follows: A major wash across the basal cells beyond arculus, involving about one-half the length of cells  $R$ ,  $M$  and  $Cu$ , the basal two-thirds of 1st  $A$  and all of 2nd  $A$ , the prearcular field paler; a broad brown band at cord, extending from stigma back to vein  $Cu$ , in cases so wide along the cord as to completely fill cell 1st  $M_2$ ; conspicuous seams along the whole length of  $Rs$ , all of vein  $Cu$ , cell  $C$  and the outer radial margin to the wing-apex; cell  $Sc$  slightly more yellowish brown, a little paler than cell  $C$  but darker than the ground; veins brown, veins  $C$ ,  $Sc$ ,  $R$  and the prearcular field more yellowish brown. Venation:  $Sc$  long,  $Sc_1$  ending just before fork of  $Rs$ ,  $Sc_2$  at its tip;  $Rs$  very strongly arcuated at origin, in longitudinal alignment with  $R_5$ ;  $R_{3+4+5}$  perpendicular at origin; both branches of  $Rs$  long and extending generally parallel to one another for their entire length, cell  $R_2$  at margin thus very extensive; cell 1st  $M_2$  short, subquadrate in outline, much shorter than any of the veins beyond it;  $m-cu$  at or very close to fork of  $M$ .

Abdominal tergites brownish black, the sternites paler, yellowish brown. Male hypopygium with the basistyle simple. Outer dististyle small, straight, the apex weakly and obtusely bilobed. Inner dististyle longer than the outer, its apex a compressed cultriform blade. What appear to represent gonapophyses are flattened blades directed mesad. Aedeagus simple, broad at base, the short apex slender and straight.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, March 21, 1940 (MacIntyre). *Paratopotype*, ♂, with the type.

I am assigning this very distinct and interesting fly to *Elephantomyia* with the realization that it deviates from the characters of the genotype in certain respects, notably the venation and the structure of the male hypopygium, such as the simple aedeagus. The possibility is not excluded that further collections and more material in this immediate

group will require a new subgeneric group for the fly. The species is readily told from all other regional species of the genus by the conspicuously patterned wings, the only other species showing this character being *Elephantomyia* (*Elephantomyia*) *supernumeraria* Alexander, belonging to a distinct subgenus and readily told by the presence of a supernumerary crossvein in cell  $R_3$  of the wings.

### **Teucholabis** Osten Sacken

#### **Teucholabis** (*Teucholabis*) *spica* sp. n.

Belongs to the *melanocephala* group; general coloration of mesonotum polished yellow, the praescutum with three more reddish stripes, the cephalic portions of the lateral stripes blackened; scutellum and mediotergite yellow; pleura chiefly dark; femora yellow, with two narrow brown rings, both before the tip; a modified area on proximal end of posterior basitarsus in male; wings light yellow, with three pale brown crossbands, the last one narrow and apical; cell *1st M*<sub>2</sub> closed; male hypopygium with the spine of basistyle terminating in two slender blackened points.

*Male*.—Length, about 10 mm.; wing, 8.3 mm.

Rostrum black above, paler beneath; palpi black. Antennae with scape brown, pedicel and flagellum black; flagellar segments cylindrical; longest verticils unilaterally distributed, about twice the length of the segments. Head with the front pale, the vertex polished black, paling to reddish behind.

Cervical region black. Pronotum obscure yellow. Mesonotal praescutum polished yellow, with three more reddish stripes, the cephalic portions of the lateral stripes blackened; scutum yellow, the lobes with polished black areas; scutellum and mediotergite yellow, the pleurotergite extensively dark brown, its posterior border yellow. Pleura dark liver brown, the dorsal sternopleurite with an extensive area of appressed silvery setulae; posterior border of pteropleurite with a group of long yellow setae. Halteres with stem yellow, knob weakly darkened. Legs with the coxae yellow, the fore and middle pair weakly infuscated; trochanters yellow; femora yellow, each with two narrow and poorly indicated brown rings, the outer narrow, less than its own length before the tip, the second dark ring at or before midlength, broader and more diffuse on posterior legs; tibiae and tarsi yellow, the terminal tarsal segments dark brown; posterior basitarsi weakly dilated and provided with a modified area at proximal end. Wings light yellow, with three pale brown crossbands, the most basal extending from cell *R* into cell *2nd A*; second band broad, lying at, but chiefly beyond, the cord, completely filling cell *1st M*<sub>2</sub>; apical band small and restricted, including only the wing-tip from cell  $R_3$  to *2nd M*<sub>2</sub>, inclusive; stigma oval, darker brown, included in the second dark band; veins light yellow, brown in the darkened areas. Costal fringe short but dense. Venation:  $Sc_1$  ending about opposite midlength of the arcuated  $Rs$ ,  $Sc_2$  at near one-sixth the  $R_3$  oblique, longer than  $R_{1+2}$ , the latter strongly upcurved to the



margin; cell 1st  $M_2$  nearly as long as vein  $M_3$  beyond it;  $m-cu$  about one-third its length beyond fork of  $M$ ; cell 2nd  $A$  wide.

Abdomen yellow, darkened laterally, leaving the median region paler; hypopygium weakly infuscated. Sternal pocket very conspicuous, as in the *melanocephala* group. Male hypopygium with the spine of basistyle a strong erect rod that is split at apex into two black spines, one a direct prolongation of the axis, the other slightly longer, directed at a right angle and mesad; flange of basistyle long and conspicuous, its margin with microscopic black teeth. Outer dististyle a gently sinuous simple rod that is more than one-half longer than the rod of basistyle, its tip an acute spinous point. Inner dististyle with the beak terminating in an acute black spine.

*Holotype*, ♂, Abitagua, Cunibunda, altitude 1,100 meters, April 2, 1940 (MacIntyre).

*Teucholabis* (*Teucholabis*) *spica* is related to other Neotropical species of the group having cell 1st  $M_2$  closed, these including *T.* (*T.*) *angustapicalis* Alexander, *T.* (*T.*) *catharinensis* Alexander, *T.* (*T.*) *inulta* Alexander, *T.* (*T.*) *melanocephala* (Fabricius), *T.* (*T.*) *oteroi* Alexander and *T.* (*T.*) *perangusta* Alexander. It differs from all of the above in the pattern of the body, wings and legs, but especially in the structure of the male hypopygium, notably the bispinous lobe of the basistyle. It is apparently closest to *inulta* yet very distinct.

#### *Teucholabis* (*Teucholabis*) *perlata* sp. n.

Size large (male, length about 9 mm.); general coloration yellow, the praescutum darkened on anterior portion; a conspicuous black area on dorsal portion of pleurotergite; halteres with yellow knobs; legs black, the tarsi paling to obscure yellow; wings very broad, grayish subhyaline, restrictedly patterned with darker, including a narrow seam along cord; male hypopygium with the arm of basistyle unusually long and slender, sinuous, at apex abruptly narrowed into a black spine; outer dististyle a simple flattened pale blade, gently widened outwardly, provided with numerous black setae on outer portion of distal two-thirds.

*Male*.—Length, about 9 mm.; wing, 8 x 3 mm.

Rostrum and palpi black, the former relatively short. Antennae black. Head dark-colored.

Pronotum dark. Mesonotal praescutum chiefly dark liver brown, paling to yellow on the posterior interspaces and near the suture, the anterior median portion more intensely darkened to almost black; scutum yellow, the lobes weakly darkened; scutellum and postnotum yellow. Pleura yellow, the pleurotergite with a major black area on dorsal portion; meral region slightly darkened. Halteres with stem dusky, knob light yellow. Legs with coxae and trochanters obscure yellow; femora black, scarcely paler basally; tibiae black; tarsi abruptly paler, obscure yellow. Wings unusually broad, as shown by the measurements; ground color grayish subhyaline, with a very restricted darkened pattern, including the stigma and a narrow seam along the cord; veins brown. Venation:  $Sc$  long,  $Sc_1$  ending beyond midlength of  $R_s$ ,  $Sc_2$  a short distance back from its

tip;  $R_2$  a little longer than  $R_{1+2}$  and subequal to  $R_{2+3+4}$ ;  $m-cu$  about three-fourths its length beyond fork of  $M$ .

Abdomen pale brownish yellow, possibly not fully colored; hypopygium darker. Sternal pockets of male only feebly developed. Male hypopygium with the arm of basistyle unusually long and slender, sinuous, at apex abruptly narrowed into an acute black spine; before this spine, the precipitous portion of the arm provided with delicate setulae. Outer dististyle a simple flattened pale blade, gently widened outwardly, the apex truncated, the outer portion of distal two-thirds with numerous black setae. Inner dististyle with the apical beak blackened and nearly truncated, the usual two points or denticles greatly reduced. Aedeagus at apex produced laterad into a short decurved blackened point.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, April 14, 1940 (MacIntyre).

The nearest ally of this large and conspicuous species appears to be the very different *Teucholabis* (*Teucholabis*) *mendax* Alexander, which has certain of the structures of the hypopygium of the same general type though differing conspicuously in details. The flattened outer dististyle that is widened outwardly is very unusual in the subgenus. The general appearance of the fly, especially the yellow tarsi, is more like *T. (T.) flavihorax* (Wiedemann) and relatives but the true affinities appear to be as discussed.

### ***Teucholabis* (*Teucholabis*) *distifurca* sp. n.**

General coloration brown, the praescutum without a differentiated pattern; rostrum long and slender; halteres black throughout; wings with a strong uniform dark brown tinge, the prearcular field more yellow;  $Sc$  long; abdomen brownish black; male hypopygium with the outer dististyle a blackened clavate structure, at apex bearing two strongly divergent spines of nearly equal size; apical spine of aedeagus small, simple, directed laterad.

*Male*.—Length, about 5.5 mm.; wing, 5.7 mm.

Rostrum relatively long and slender, nearly as long as remainder of head, black throughout; palpi black. Antennae black; flagellar segments oval, strongly constricted at the incisures, the outer segments more elongate. Head dark brown.

Pronotum obscure yellow, narrowly darkened on extreme lateral portion. Mesonotal praescutum medium brown, without pattern, darker behind, the surface somewhat polished; humeral region a trifle brightened; posterior sclerites of notum brown. Pleura obscure reddish brown, the dorsal region darker, especially before and beneath the wing-root. Halteres black throughout. Legs with the coxae reddish brown; trochanters obscure yellow; remainder of legs broken. Wings with a strong, uniform, dark brown tinge, cell  $C$  and the prearcular region more yellow; stigma a trifle darker than the ground, oval; veins dark brown, brighter in the prearcular field. Setae of basal costal region long and conspicuous, becoming shorter and more dense on outer portion of vein. Venation:  $Sc$  long,  $Sc_1$  ending about

opposite three-fourths  $R_5$ ;  $Sc_2$  a short distance from its tip;  $Sc_1$  alone a little longer than vein  $R_5$ ; cell 1st  $M_2$  long and narrow, gently widened outwardly;  $m-cu$  about one-third to one-fourth its length beyond the fork of  $M$ .

Abdomen brownish black, the basal sternites a trifle brightened; sternal pocket strongly darkened and thus differentiated in color but with relatively few setae. Male hypopygium with the lobe of basistyle straight, the distal third further produced into a glabrous black spine, the lobe basad of this with abundant long yellow setae. Outer dististyle a blackened setiferous club, at apex bearing two strong black divergent spines of nearly equal size. Inner dististyle with the apical beak simple, appearing as a blackened curved blade, the tip acute. Aedeagus with the apical spine small, simple, directed laterad.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, March 21, 1940 (MacIntyre).

*Teucholabis* (*Teucholabis*) *distifurca* is very similar in its general appearance to *T. (T.) atripennis* Alexander, likewise from the Oriente of Ecuador, differing very conspicuously in the structure of the male hypopygium, especially the apical lobe of the basistyle, the entirely different dististyles, and in the apical spine or elongate lobe of the aedeagus. Since the legs of the present fly are broken, it cannot be stated as to whether or not there is any modification of the posterior tibiae as in *atripennis*.

## Molophilus Curtis

### *Molophilus* (*Molophilus*) *debilius* sp. n.

Belongs to the *plagiatus* group; general coloration brownish black, the lateral portions of the praescutum more reddish brown; antennae relatively long, about one-half the length of body, black throughout; flagellar segments with long outspreading pale setae and unusually long, unilaterally distributed verticils; male hypopygium with the beak of basistyle unusually slender; basal dististyle a small pale rod that narrows to a slender straight spine.

*Male*.—Length, about 3 mm.; wing, 3.5 mm.; antenna, about 1.4 mm.

Rostrum dark brown; palpi black. Antennae black, relatively long; flagellar segments oval to fusiform, with long outspreading pale setae and much longer verticils that are unilaterally arranged, one to each segment, the longest of these exceeding twice the length of the segment. Head brown.

Mesonotum reddish brown, the central portion of praescutum dark brown or brownish black; posterior sclerites of notum more uniformly brownish black. Pleura brownish black throughout. Halteres blackened, only the base of stem restrictedly paler. Legs with the coxae brownish testaceous; trochanters paler; remainder of legs brownish yellow, appearing much darker because of the abundant black vestiture. Wings relatively broader, strongly suffused with brown, the stigmal region even darker; veins pale brown. Venation:  $R_2$  lying a short distance beyond level of  $r-m$ ; petiole of cell

*M*<sub>3</sub> less than twice *m-cu*; vein 2nd *A* gently sinuous, ending a short distance beyond *m-cu*.

Abdomen, including hypopygium, brownish black. Male hypopygium with the beak of basistyle unusually slender. Both dististyles placed close together at their bases; outer style heavily blackened, the slender arm a little longer than the truncated one, the tip acute. Basal dististyle a small pale rod that is about equal in total length to the outer dististyle but much paler and weaker, with a little more than the basal half widened, thence narrowed to a long straight spine, at the base of the latter with a small tuberculate point. Phallosomic plate relatively narrow, the apex obtuse.

*Holotype*, ♂, Abitagua, altitude 1,100 meters, March 18, 1940 (MacIntyre).

The general structure of the male hypopygium of the present fly is somewhat similar to that of *Molophilus* (*Molophilus*) *ductilis* Alexander, yet the species is very distinct from this and all other described members of the genus.

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MONOGRAPH OF THE SOUTH AMERICAN WEEVILS OF THE GENUS  
*CONOTRACHELUS*, by KARL FIEDLER. Pages 1-365, 56 figs., 1 pl. (in German), 1940. Published by the British Museum. Price 15s. 0d.

From the preface we quote: "Dr. Karl Fiedler, Sanitätsrat in Suhl, Turingia, first turned his attention to American weevils about the year 1929. After publishing a number of short papers it was suggested to him by Dr. van Emden of the Dresden Museum, that the genus *Conotrachelus* greatly needed attention." The whole of the undetermined *Conotrachelus* material in the British Museum, from the time of H. W. Bates' expedition to the Amazons was lent to Dr. Fiedler for examination. He reported on returning the material, that he had described 216 new species and that some 600 species occurred in that region.

In June, 1937, the Trustees agreed to publish Dr. Fiedler's Revision in view of the fact that many of the species are pests on cacao, custard apple, guava, certain legumes, and on stone fruits such as plums and apricots. To avoid inaccuracies of translation it was ordered published in the original German text.

With only five pages of introductory matter the volume plunges directly into taxonomy. The first key divides the genus into six Groups each of which has its key on later pages. The descriptions are short, from one to three (in eleven point type) to a page. Genitalia are not figured, if used at all. The remarkably rich configuration of the surfaces of the beetles, particularly of the elytra takes most of the description space. The illustrations, sixty-five in all, are dorsal views of whole beetles and, except for nine on one plate (frontispiece), are scattered through the text.—C. H. K.

# THE INSECT INQUILINES AND VICTIMS OF PITCHER PLANTS IN NORTH CAROLINA

D. L. WRAY and C. S. BRIMLEY,

Division of Entomology, State Department of Agriculture,  
Raleigh, N. C.

Pitcher plants have long attracted attention because of their carnivorous habits and their striking unlikeness to any other plants found in this country. It is the purpose of this paper to give the results of studies on the insects and other creatures found in the pitchers.

Because of its availability and abundance, *Sarracenia flava* was the chief species of pitcher plant from which collections were made. Collections were made from this species at Raleigh (May 20 to July 4, October 28, and November 11 in 1938, and May 11 to 30 in 1939), Fayetteville (May 14 to August 3 in 1939, and May 15 to June 27 in 1940), Wilmington (May 15, 1940), Council (May 16, 1940), and Orton (May 2, 1939). The Raleigh locality consisted of a small bog about a quarter acre in size surrounded by a thicket of shrubs, and was well watered by a seepage of springs; there was a good growth of pitchers in this bog, some reaching 54 inches in height. The collections at Fayetteville were made in a bog about four acres in size where the pitchers grew luxuriantly in large round clumps.

Limited collections were made from pitchers of *Sarracenia purpurea* at Raleigh (May 17, 1939), Highlands (August 1, 1938), Pinehurst (May 30, 1938), Hoffman (June 1, 1938), and Southern Pines (June 1, 1938). One collection was made from pitchers of *S. rubra* at Hoffman (June 1, 1938).

The insects and other creatures, whether dead or alive, were taken from the pitchers and put in alcohol, either in the field or after the pitchers had been brought in to the laboratory. Later on the specimens from each lot were sorted out and classified as nearly as possible. No count was made of the number of pitchers collected, but a minimum estimate of five thousand would not be excessive.

Some data were taken on the height of the leaves and the depth of the pitchers in relation to the insects caught, but they were not sufficiently complete to warrant their inclusion in this paper.

## LIST OF INSECTS FOUND IN SARRACENIA FLAVA<sup>1</sup>

As the localities where collections were made are few in number, they will be represented only by their initials, followed by the number of specimens taken at each place, as follows: R, Raleigh; F, Fayetteville; W, Wilmington; O, Orton; C, Council.

The list is arranged by orders in their proper sequence.

<sup>1</sup>In order to condense the text, the names of authors of species have been omitted. These names can be found in "The Insects of North Carolina," by C. S. Brimley, 1938, which list has been followed in this paper.

**ORTHOPTERA. Blattidae.** *Cariblatta lutea*, R 11; *Ischnoptera deropeltiformis*, R 1, F 2; *Parcoblatta lata*, R 2; *P. sp.*, C 2; *Parcoblatta* nymphs, R 4; and wings of another cockroach, F 1. **Tettigoniidae.** *Neoconocephalus robustus crepitans* (teneral), R 2; *N. sp.*, F 3; *Atlanticus pachymerus*, R 2; *A. sp.*, R 1; nymphs, R 6. **Gryllidae.** *Nemobius* nymph, R 2. **Acridiidae.** Nymphs, C 1, F 5; *Leptysma marginicollis*, F 1. **Acrydiidae.** *Acrydium sp.*, W 1, C 2; *Tettigidea lateralis*, C 1, F 1.

**ISOPTERA. Termitidae.** *Reticulitermes virginicus*, R 2, May.

**NEUROPTERA. Sialidae.** *Sialis concava*, F 1; *S. sp.*, R 1. **Hemerobiidae.** R 4, F 2. **Chrysopidae.** *Chrysopa oculata*, F 1; *C. rufilabris*, F 6, two alive; *C. sp.*, F 1. **Ascalaphidae.** One larva, F, August.

**THYSANOPTERA.** One thrips, F, May.

**HEMIPTERA. Cydnidae.** *Galgupha sp.*, R 2, W 1, F 1; *Corimelaena sp.*, R 2. **Pentatomidae.** *Podops cinctipes*, R 4; *Brochymena arborea*, F 1; *B. quadripustulata*, R 1; *Trichopepla semivittata*, R 1; *Mormidea lugens*, R 14, C 2, F 11; *Solubea pugnax*, F 1; *Euschistus servus*, R 2, F 2; *E. tristigmus*, R 11, F 3; *Thyanta calceata*, R 1; *T. custator*, C 4, W 1; *Acrosternum hilare*, R 1; *Podisus maculiventris*, F 1. **Coreidae.** *Acanthocephala terminalis*, F 1; *Leptoglossus oppositus*, R 5, F 2; *Coriscus pilosulus*, R 1; *Harmostes reflexulus*, C 9, F 1; *Corizus bohemani*, R 1; *C. lateralis*, F 1; *C. sp.*, C 2. **Neididae.** *Jalysus spinosus*, R 1, F 1, May. **Lygaeidae.** *Lygaeus bicrucis*, W 2, C 3, F 80; *Nysius californicus*, C 7; *N. sp.*, F 4; *Ischnorhynchus resedae*, R 1; *Geocoris sp.*, R 1; *Oedancala dorsilinea*, R 4; *O. sp.*, C 1, F 6, R 4; *Myodocha serripes*, R 1, F 2; *Orthaea bilobata*, F 5; *O. longula*, R 1, F 9; *O. servillei*, F 1. **Pyrrhocoridae.** *Euryophthalmus succinctus*, F 1. **Tingitidae.** *Corythuca sp.*, R 1. **Reduviidae.** *Oncerothachus acuminatus*, R 4, one of which was a nymph; *Stenopoda cinerea*, R 3 nymphs; *Rhiginia cruciata*, R 1; *Fitchia aptera*, C 1; *Sinea spinipes*, R 2; nymphs, R 2. **Nabidae.** *Nabis capsiformis*, W 1, C 1; *N. sp.*, R 1, F 4. **Miridae.** *Neurocolpus nubilus*, R 1; *Adelphocoris rapidus*, R 4, W 1, C 3; *Lygus pratensis*, R 5; other Hemiptera, R 3.

**HOMOPTERA. Cercopidae.** *Monecophora bicincta*, R 2, F 1; *Aphrophora sp.*, F 1; *Clastoptera sp.*, R 2. **Membracidae.** *Ceresa brevitylus*, R 1; *C. sp.*, O 16, F 4, R 2; *Stictocephala sp.*, R 19, O 9, C 11, F 5; *Acutalis semicrema*, F 1; *Eutylia sp.*, R 1, F 3. **Cicadellidae.** *Oncometopia lateralis*, C 2, F 1; *O. undata*, R 16, W 1, C 2, F 31; *Aulacizes irrorata*, W 1, C 1, F 12; *Graphocephala coccinea*, R 5; *G. versula*, R 4, C 1, F 11; *Gypona miliaris*, C 1, *G. octolineata*, R 1; *G. sp.*, R 4, C 6, F 8; *Platymetopius frontalis*, R 2; *Euscelis anthracinus*, R 1; *Phlepsius sp.*, R 3, C 3, F 9; *Jassus olitorius*, R 1; unidentified, O 1, F 9, R 41. **Fulgoridae.** *Acanalonia bivittata*, R 1; *Liburniella ornata*, R 1; unidentified, C 3, F 4, R 4. **Psyllidae.** R 1, F 1. **Aphidae.** R 67, F 13.

**COLEOPTERA. Carabidae.** *Calosoma externum*, F 1; *Leptotrachelus dorsalis*, R 1, F 2; *Galerita sp.*, F 2; *Lebia analis*, R 10, F 23; *L. collaris*, R 2, C 2, F 2; *L. ornata*, R 31, C 1, F 1; *L. scapularis*, F 1, May; *L. viridipennis*, R 2, F 1; *L. viridis*, R 3; *L. sp.*, R 29, C 2, F 6; *Helluomorphia sp.*, F 1; *Harpalus pennsylvanicus*, F 1; *H. sp.*, F 3; unidentified, R 7, W 11, F 16. **Staphylinidae.** *Pinophilus latipes*, R 1; *Staphylinus*

*cinnamopterus*, R 1; *S. sp.*, R 1; unidentified, R 3. **Histeridae**. R 2, May. **Lycidae**. *Lycostomus lateralis*, F 1; *Eros sp.*, F 1; *Plateros sp.*, C 5, W 3; unidentified, F 1. **Lampyridae**. *Lucidota atra*, R 1; *L. sp.*, O 1; *Photinus pyralis*, R 2; *P. sp.*, R 6, F 1; *Photuris pennsylvanica*, R 7, W 16, F 7, C 3; unidentified, R 1 small species. **Cantharidae**. *Chauliognathus marginatus*, R 281, O 13, W 17, C 9, F 279; *Podabrus rugulosus*, F 1; *P. sp.*, R 12, W 4, C 3, F 19; *Cantharis sp.*, R 79, W 20, C 3, F 113; unidentified, R 35. **Melyridae**. *Collops quadrimaculatus*, F 4. **Cleridae**. *Enoclerus rosmarus*, R 43; *Hydnocera humeralis*, R 7, C 1; unidentified, R 16, F 1. **Oedemeridae**. *Oxaxis taeniata*, F 1. **Mordellidae**. R 53, C 1, F 14. **Anthicidae**. *Notoxus sp.*, F 1. **Elateridae**. *Monocrepidius lividus*, R 1, F 1; *M. vespertinus*, C 1, F 8; *Ludius pyrrhos*, R 3; *Orhostethus infuscatus*, F 1; *Melanotus communis*, W 22, C 15, F 1; unidentified, R 12, W 31, C 21, F 37. **Buprestidae**. *Acmaeodera tubulus*, R 1, F 1; *Anthaxia quercata*, F 1; *Agrilus vittaticollis*, R 2; *A. sp.*, R 2; *Brachys ovatus*, R 1, F 5; unidentified, R 1. **Helodidae**. *Helodes pulchella*, F 1; *Prionocyphon discoideus*, R 1; *Ptilodactyla serricollis*, R 9, F 2. **Nitidulidae**. *Carpophilus sp.*, R 1; *Glischrochilus quadrisignatus*, F 2; unidentified, R 2, F 1. **Cucujidae**. *Telephanus velox*, R 2, F 2. **Erotylidae**. *Languria mozardi*, R 1; *Acropteroxys gracilis*, R 1; *Tritoma humeralis*, F 1; unidentified, F 2. **Coccinellidae**. *Hyperaspis gemina*, F 2; *H. sp.*, R 1; *Psyllobora vigintimaculata*, R 2; *Ceratomegilla fuscilabris*, R 227, W 3, C 43, F 56; *Hippodamia convergens*, R 4, W 4, C 2, F 16; *Cycloneda munda*, R 111, O 2, W 1, C 4, F 7; *Olla plagiata*, R 1, F 3; *Adalia bipunctata*, R 1; *Chilocorus bivulnerus*, R 2; *Epilachna varivestis*, C 1, F 4; unidentified, R 2, O 2. **Alleculidae**. R 1, O 1, F 1. **Melandryidae**. R 1. **Anobiidae**. R 3. **Scarabaeidae**. *Onthophagus hecate*, R 2; *Aphodius sp.*, R 1; *Dialytes sp.*, F 1; *Serica sp.*, R 5; *Phyllophaga micans*, C 3, F 2; *P. ulkei*, F 2 females; *P. sp.*, R 4, W 12, C 1, F 9; *Euphoria sepulcralis*, R 2, W 1, F 1; *Trichiotinus piger*, R 1. **Cerambycidae**. *Hypermallus villosus*, C 4; *Elaphidion mucronatum*, F 1; *Heterachthes ebenus*, F 2; *Typocerus zebra*, W 2, C 4; *T. velutina*, R 1; *Ancylocera bicolor*, F 1; *Leiopus alpha*, R 1; *Hyperplatys aspersa*, R 2; *Oberea myops*, R 2; unidentified, O 1. **Chrysomelidae**. *Lema sexpunctata*, F 3; *L. sp.*, R 1; *Chlamys gibbosa*, R 4; *Pachybrachys sp.*, R 1; *Bassareus lativittis*, C 2; *Colaspis brunnea*, F 1; *Paria canella*, R 40, O 1; *Galerucella sp.*, R 15; *Diabrotica 12-punctata*, R 33, C 2, F 37; *D. vittata*, R 14, F 5; *Cerotoma trifurcata*, R 101, F 6; *Oedionychis circumdata*, R 1; *O. miniata*, R 1; *O. sp.*, R 32, C 3, F 3; *Disonychia abbreviata*, R 6; *D. caroliniana*, R 1; *D. discoidea*, R 1; *D. leptolineata texana*, R 1; *D. sp.*, F 1; *Halitica sp.*, C 1; *Systema hudsonias*, R 3; *S. sp.*, F 2; *Hispinae*, R 3; *Chalepus bicolor*, R 1, *C. dorsalis*, F 1; *C. scapularis*, R 1; *Baliosus ruber*, R 3; *Chirida guttata*, R 2; unidentified, R 7, F 3. **Bruchidae**. *Bruchus sp.*, R 1. **Platystomidae**. *Anthribius cornutus*, W 1. **Curculionidae**. *Eugnamptus puncticeps*, C 1; *E. sp.*, R 10; *Attelabus analis*, C 2; *Apion sp.*, F 3; *Otidocephalus sp.*, R 1; *Lixus concavus*, R 2, W 1; *Geraeus picumnus*, R 179, C 7, F 130; *Conotrachelus nenuphar*, R 1; *C. seniculus*, R 5; *C. sp.*, F 3; unidentified, R 3, W 1, C 2, F 5. **Rhynchophoridae**. *Rhodoabaenus sp.*, R 2. **Scolytidae**. R 1, F 1. Unidentified Coleoptera, F 28.

**MECOPTERA. Panorpidae.** *Panorpa americana*, R 1; *P. sp.*, R 19, F 8, W 1.

**TRICHOPTERA. Phryganeidae.** *Neuronia postica*, F 2; unidentified Trichoptera from Fayetteville 4.

**LEPIDOPTERA. Satyridae.** *Neonympha eurytus*, R 1; *N. sosybius*, R 1, F 1. **Hesperiidae.** R 1. **Arctiidae.** *Halisidota sp.*, F 1; *Estigmene acrea*, F 1. **Noctuidae.** *Heliothis obsoleta*, F 1; *Feltia annexa*, F 1 alive; *F. sp.*, F 1; *Agrotis ypsilon*, R 2; *Lycophotia margaritosa saucia*, R 2; *Lacinipolia laudabilis*, R 1; *Eriopyga crenulata*, R 1; *Cirphis juncicola*, R 1; *Perigaea sutor*, F 1 alive; *Exyra ridingsi*, R (many of these were found alive as inquilines in the pitchers from mid-May to later on in the fall, even as late as November 11); *Autographa sp.*, R 1 larva; unidentified, R 74 plus 2 larvae, O 2, F 29. **Geometridae.** R 3 larvae found. **Thyridae.** *Thyris lugubris*, R 1. **Pyalidae.** *Desmia funeralis*, R 1. **Aegeriidae.** R 1. Unidentified moths, R 201, W 14, C 33, F 74, O 4; moth larvae, R 1; larvae pitcher plant moths (inquilines), R many, these were very numerous and not all were counted.

**DIPTERA. Ptychopteridae.** *Ptychoptera rufocincta*, F 1; *Bittacomorpha clavipes*, F 1. **Tipulidae.** *Geranomyia rostrata*, O 1, F 15; *Rhipidia domestica*, R 10, *R. maculata*, R 4; *Limonia triocellata*, R 3, F 1; *Erioptera caloptera*, F 2, *E. parva*, F 2; *Gnophomyia luctuosa*, R 1, F 2; *Orosia innocens*, R 40; *Epiphragma solatrix*, F 3; *Limnophila fuscovaria*, R 2, F 1; *L. luteipennis*, R 2; *L. macrocera*, R 3, F 3; *Tricyphona inconstans*, R 1, O 1, F 7; *Nephrotoma sp.*, R 1, F 1; *Tipula perlongipes*, R 3; *T. sayi*, F 6; *T. tricolor*, R 7, F 10, O 1, W 1; *T. sp.*, R 2; unidentified, R 23, O 6, C 1, F 23. **Culicidae.** R 3. **Mycetophilidae.** *Mycetophila sp.*, R 3, F 12; *Sciara sp.*, R 7, C 1, F 3; *Neosciara sp.*, R 1; unidentified, R 9, O 6, W 1, F 2. **Rhagionidae.** *Chrysopilus sp.*, R 8; *C. fasciatus*, R 1; *C. rotundipennis*, R 3; unidentified, R 1. **Stratiomyidae.** *Allognosta fuscitarsis*, R 1; *A. obscuriventris*, R 5, W 1; *A. sp.*, R 5; *Hermetia illucens*, R 2, F 3; *Odontomyia sp.*, R 7; *Oxycera albovittata*, F 1; *O. variegata*, F 1; unidentified, F 3. **Tabanidae.** *Chrysops celer*, W 1; *C. flavida*, F 1; *Chrysops sp.*, F 4 males; *Tabanus sp.*, R 1, F 1; *T. pumilis*, F 1. **Asilidae.** *Leptogaster sp.*, R 1; *Asilus sp.*, R 1. **Therevidae.** *Epomyia pictipennis*, F 5; *Psilocephala haemorrhoidalis*, R 6, F 4; unidentified, R 2, F 3. **Empididae.** *Syneches rufus*, R 1; *Empis poeciloptera*, F 1; *Rhamphomyia sp.*, F 14; unidentified, R 1, F 2. **Dolichopodidae.** *Sciapus sp.*, R 1, C 1; *Dolichopus sp.*, F 2; unidentified, R 13, O 2, W 2, F 9. **Syrphidae.** *Microdon sp.*, R 1; *Chrysogaster nitida*, R 1; *Toxomerus sp.*, W 1; *Baccha tarchetius*, R 1; *Eristalis tenax*, R 4, F 6; *Xylota pigra*, R 1; *X. sp.*, F 1; *Syrilla pipiens*, F 1; unidentified, F 1. **Pyrgotidae.** *Pyrgota undata*, C 1. **Phasiidae.** *Trichopoda radiata*, R 1. **Tachinidae.** *Ormia signifera*, F 1; *Siphona geniculata*, R 1; *Bonnetia comta*, F 1; *Winthemia rufopicta*, W 1; *Euthera tentatrix*, F 1; unidentified, R 2, C 2, F 9. **Dexiidae.** *Thelaira nigripes*, R 1. **Sarcophagidae.** *Neophytolmaba*, W 1; *Camptopsis miamensis*, R 3; *Sarcophaga sp.*, R 18, W 1 female, F 3; *Sarcophaga* larvae (inquilines) in almost every pitcher; unidentified, R 9, C 4. **Calliphoridae.** *Cochliomyia macellaria*, F 5; *Lucilia sp.*, R 46, F 30. **Muscidae.** *Musca domestica*, R 16, F 2; *Morellia micans*, F 1; *Muscina sp.*, R 3, F 3, C 1. **Anthomyiidae.** R 7, O 2, W 3,



C 8, F 15. **Scatophagidae.** *Parallelomma munda*, R 2; *Achaetella varipes*, R 2; *Scatophaga furcata*, R 1. **Helomyzidae.** F 1. **Sciomyzidae.** *Tetanocera clara*, R 1; *T. vicina*, R 1, F 1; unidentified, R 48, C 1, F 5. **Sapromyzidae.** *Minettia* sp., R 1; *Sapromyza* sp., R 1; unidentified, R 6, F 1. **Ortaliidae.** *Rivellia quadrifasciata*, F 6; *R. sp.*, R 5; *Camptoneura picta*, R 1, F 4; *Euxesta notata*, F 1; *Chaetopsis fulvifrons*, R 12, F 6; *Stenomomyia tenuis*, C 1. **Trypetidae.** *Zonosema electa*, F 2; *Eutreta sparsa*, R 1; *E. sp.*, R 1; *Trypanea actinobola*, C 1; unidentified, R 1. **Sepsidae.** *Sepsis violacea*, R 17, F 4. **Psilidae.** R 1. **Ephydriidae.** R 1. **Chloropidae.** *Meromyza americana*, F 1; unidentified, R 1, W 1, F 3. **Drosophilidae.** *Drosophila sigmoides*, R 4; unidentified, R 4.

HYMENOPTERA. **Tenthredinidae.** *Strongylogaster tacitus*, R 1; unidentified, R 24, O 1, W 5, C 2, F 6. **Braconidae.** *Bassus spiracularis*, R 1; unidentified, R 8, W 1, F 2. **Ichneumonidae.** *Amblyteles comptus*, R 1; *A. maurator*, R 3; *A. pullatus*, F 1; *A. signalipes*, R 1; *A. (near) tumidifrons*, R 1; *A. w-album*, R 11; *A. sp.*, R 1; *Spilocryptus nunciatus*, R 1; *Cryptus sp.*, R 1; *Diapetimorpha orba*, R 1, F 1; *Mesostenus thoracicus*, R 1; *Ephialtes aequalis*, R 3; *E. conquisitor*, W 1; *Diplazon laetatorius*, R 2; *Eremotylus archiae*, R 1; unidentified, R 56, W 2, C 11, F 22. **Cynipidae.** *Amphibolips* sp., R 1; unidentified, R 1, C 1, F 3. **Perilampidae.** R 2. **Chalcididae.** *Spilochalcis mariae*, C 1; other chalcids, F 10, R 26. **Formicidae.** *Crematogaster* sp., R 1567, O 6, W 1000 plus, C 1000 plus, F 6; *Camponotus castaneus*, C 1, F 4; unidentified, R est. 871, O 3, F est. 90. **Psammocharidae.** *Ageniella accepta*, F 2 (one male); *A. iridipennis*, R 1; *Pseudagenia architecta*, R 2; *P. caerulescens*, F 1; *P. mellipes adjuncta*, R 3, F 1; *Priocnemis* sp., F 1; *Planiceps niger*, C 2; *Pedinaspis legatus*, W 2 males, C 2 males and 2 females; *Episyron snowi*, F 1; *Psammochares* sp., R 4; *Sericopompilis posticatus*, C 1; *Lophopompilus atrox*, F 1; *Pompiloides* sp., F 1; *Nannopompilus argenteus*, R 1, C 8; unidentified, R 11. **Chrysididae.** *Notozus* sp., R 1; *Chrysis tridens*, F 1; *C. sp.*, R 1, W 1; unidentified, R 3, F 1. **Tiphiidae.** *Myzine* sp., W 1, F 1 male; *Tiphia* sp., R 5, W 11, F 3 females. **Mutillidae.** *Timulla* sp., F 1 male. **Vespididae.** *Ancistrocerus* sp., R 1; *Odynerus megaera*, R 1; *O. sp.*, R 2, F 2; *Polistes annularis*, R 3; *P. fuscatus*, R 12; *P. hunteri*, R 2; *P. rubiginosus*, R 3, F 1; *P. variatus*, F 2; *P. sp.*, C 1; *Vespula maculifrons*, R 4; *V. squamosa*, R 1, F 1 queen. **Sphecidae.** *Tachytes* sp., F 2; *Trypoxylon* sp., R 1; *Chlorion harrisi*, R 3; *C. ichneumonenum*, F 1; *Spheg nigricans*, F 1; *S. urnaria*, R 2, F 1; *Sceliphron cementarium*, R 5, F 1; *S. cyaneum*, R 2, F 1; *Pseninae*, R 1; *Nyssonini*: *Didineis texana*, R 1; *Paramellinus* sp., F 4; other *Nyssonini*, C 1, F 1; *Bembecini*: *Sictia carolina*, F 1; *Crabronini*: *Crabro* sp., R 3, F 1. **Halictidae.** *Augochlora fervida*, R 1; *A. sp.*, R 33, W 1, C 1; *Halictus* sp., R 2. **Megachilidae.** *Osmia* sp., R 1. **Bombidae.** *Bombus* sp., F 3. **Apidae.** *Apis mellifica*, R 8, W 1, F 32; other bees, R 29, C 5, F 6.

ARACHNIDA. ARANEAE. The Spiders. **Argiopidae** (Orb weavers). *Marxia stellata*, R 3. **Tomisidae** (Crab Spiders), R 2. **Attidae** (Jumping spiders), R 3. Unidentified spiders, R 166, W 6, C 15, F 31. OPILIONES. The harvestmen. R 13, F 2; unidentified, R 1. ACARINA. Mites were taken in pitchers at Orton (5) and at Fayetteville (1).

MOLLUSCA. Two small snails were taken at Raleigh in May, one being partly digested including the shell (May 19, 1939).

AMPHIBIA. Two small frogs, *Pseudacris ocularis* and *Hyla cinerea*, were taken alive in pitchers at Orton, May 2, 1939.

#### COLLECTIONS FROM SARRACENIAS OTHER THAN FLAVA

Limited collections were made from *S. purpurea* and *S. rubra* but the material obtained was not sufficient to furnish enough data to draw any general conclusions. The material from these two forms was as follows, listed under the head of the respective localities.

##### SARRACENIA PURPUREA AT HIGHLANDS, N. C.

August 1, 1938

ODONATA. One Libellulid nymph, the only specimen of the order obtained in all our collecting, COLEOPTERA. Four Carabids, including one *Sphaeroderus*; two Coccinellids, one of them *Ceratomegilla fuscilabris*, and the other *Hippodamia convergens*; two Elaterids; and three Scarabaeids, all *Trichiotinus affinis*. TRICHOPTERA. All four wings of a large caddis-fly. DIPTERA. One small specimen. HYMENOPTERA. A sawfly wing; Ichneumonid wing; one dealate female of the carpenter ant; and 20 winged specimens of other Formicine ants. ARACHNIDA. Two Phalangids. MOLLUSCA. One snail.

##### SARRACENIA PURPUREA AT PINEHURST, N. C.

May 30, 1938

ORTHOPTERA. One *Caribblatta lutea* and pieces of a grasshopper. DIPTERA. One dozen larvae of *Wyeomyia smithii*, and 20 of *Sarcophaga* sp., all alive and all inquilines. HYMENOPTERA. One wing of *Polistes* wasp; a queen and 8 workers of *Crematogaster*, 4 winged *Camponotus castaneus*, and 21 other ants, and a single Bethyloid. ARACHNIDA. Three spiders.

##### SARRACENIA PURPUREA AT HOFFMAN, N. C.

June 1, 1938

HEMIPTERA. One each of *Podops cinclipes*, *Cymus angustatus*, and *Antillocoris pilosulus*. COLEOPTERA. Two *Chlaenius*, and a single *Helops cisteloides*. DIPTERA. Three *Sarcophaga* larvae, a number of mosquito larvae (*Wyeomyia smithii*), and a number of other dipterous larvae, all living and all inquilines. Also about 75 *Drosophila repleta*, victims. HYMENOPTERA. A Braconid and a Psammocharid wasp. ARACHNIDA. One *Lycosa scutulata*.

##### SARRACENIA PURPUREA AT SOUTHERN PINES, N. C.

June 1, 1938

COLEOPTERA. One *Diabrotica 12-punctata*. HYMENOPTERA. One *Camponotus castaneus* and one other ant.

## SARRACENIA PURPUREA AT RALEIGH, N. C.

May 17, 1939

ORTHOPTERA. One *Cariblatta lutea* and one cockroach nymph. HEMIPTERA. One each of *Mormidea lugens* and *Myodocha serripes*, and one of another species. HOMOPTERA. One *Monocophora bicincta*. COLEOPTERA. One Mordellid, one Elaterid, one *Chauliognathus marginatus*, one *Languria mozardi*, one Coccinellid larva, and two *Geraeus picumnus*. HYMENOPTERA. One *Camponotus castaneus* and 15 *C. pennsylvanicus*, and 25 other ants. Inquilines, six larvae of *Wyeomyia smithii* and one *Sarcophaga* larva.

## SARRACENIA RUBRA AT HOFFMAN, N. C.

June 1, 1938

COLEOPTERA. Four *Ceratomegilla fuscilabris*, two *Diabrotica 12-punctata*. DIPTERA. An adult mosquito, a *Sciara*, a living *Sarcophaga* maggot, and five *Drosophila* sp. HYMENOPTERA. An Ichneumonid and the remains of a bee.

## DISCUSSION

On May 2 the pitchers had just started catching insects, as only a few were found, and some pitchers contained none. A lot gathered on July 3 showed that they had about finished catching, the few insects found at that date probably being due to accidental trapping in the pitchers. It would thus appear that the pitchers are functioning as insect traps from the middle of May until the last of June; after June most pitchers contained principally a disintegrating mass of insect remains, very little of which was identifiable. Earlier in the season the insects caught were in a comparatively good state of preservation, and occasionally specimens were found alive, thus indicating that they had recently entered the pitchers. Strong action is exerted on the insect by the pitcher plant fluid, and this becomes more profound as the season advances. The strength of the fluid is shown by the finding of a partly digested snail shell in one of the pitchers.

The insects entering the pitchers may be divided into three classes:

1. Those that find a home therein, comprising mainly the larvae of the pitcher plant moth (*Exyra ridingsi*), certain species of *Sarcophaga* larvae, and though not in the pitchers of *Sarracenia flava*, but in those of another species, *S. purpurea*, the larvae of a certain mosquito (*Wyeomyia smithii*). The moth larvae live on the tissues of the pitchers, *Sarcophaga* larvae on the dead and disintegrating insects found at the bottom of the pitchers, and the *Wyeomyia* larvae presumably on the infusoria in the water. Adult moths of *E. ridingsi* are often found resting just within the pitchers, and when disturbed usually retire further down them.

2. Regular visitors, namely, those forms that are found in sufficient numbers in the pitchers to indicate the probability that they are attracted to them by the odor of the fluid secreted by the pitchers or possibly in some cases by the odor of the decaying insects.

3. Accidentals, found in small numbers only, thus indicating that

their presence in the pitchers is presumably merely accidental, but of course it may also be due to the scarcity of said insects in the neighborhood of the pitchers. Naturally no hard and fast line can be drawn between groups 2 and 3.

In summarizing the results we find that the following orders are not represented at all: Thysanura, Collembola, Ephemera, Plecoptera, Corrodentia, Mallophaga, Anoplura, Dermaptera, Strepsiptera, and Siphonaptera.

Taking up the orders in their proper sequence, we find that in the Orthoptera no species seems to be actually attracted to the pitchers, except possibly the roach, *Cariblatta lutea*, which is represented by 11 specimens taken at Raleigh from late May to mid-June. The other species seem to be purely accidental in occurrence.

The Isoptera are represented only by two winged specimens of *Reticulitermes virginicus* taken at Raleigh in late May.

The Neuroptera are represented by only scattered specimens, for which see preceding list in this article.

In the Hemiptera the Pentatomidae are represented principally by 14 *Mormidea lugens* from Raleigh, and the same number from Fayetteville, 11 *Euschistus tristigmus* from Raleigh and three from Fayetteville. The Lygaeidae are represented by *Lygaeus bicrucis*, 80 from Fayetteville, and a few from Wilmington and Council, which makes it by far the most frequently found hemipteron. Representatives of the other families seem to be merely scattering, such common species as *Lygus pratensis* and *Adelphocoris rapidus* being represented by less than a dozen specimens.

In the Homoptera it is interesting to note that at Orton 16 specimens of a *Ceresa* were taken which comprised the bulk of insects collected in one small lot. The most numerous Membracid was a *Stictocephala* of which 19 were taken at Raleigh, 15 at Fayetteville, and 9 at Orton. The commonest Cicadellid was *Oncometopia undata*, 16 at Raleigh, 31 at Fayetteville, and three elsewhere.

In the Coleoptera the catch of Carabids was wholly scattering except with regard to the genus *Lebia*, in which *L. ornata* is represented by 31 at Raleigh and three at other places, and *L. analis* by 23 at Fayetteville and ten at Raleigh. Other *Lebias* were also taken in smaller numbers, namely *Lebia collaris* 6, *L. scapularis* one at Fayetteville which was new to the state collection, *L. viridipennis* three, and *L. viridis* three. The small number of the last species is noteworthy because it is the commonest in general collecting. Nothing further merits notice until we get to the family Cantharidae which is represented by more specimens than any other family in the whole collection, 281 specimens being taken at Raleigh of *Chauliognathus marginatus* and 279 at Fayetteville. The genus *Podabrus* is represented by 12 specimens at Raleigh and 19 at Fayetteville and several elsewhere. *Cantharis* shows up with 110 specimens at Fayetteville including a large series of the rare *C. cruralis* and 79 more *Cantharis* at Raleigh and 20 more at Wilmington.

*Enoclerus rosmarus* takes the lead in the Cleridae with 50 specimens taken at Raleigh and none elsewhere, this fully trebling the number of specimens of that species in our collection. Fifty-three unidentified

Mordellidae were taken at Raleigh and 14 at Fayetteville. Of the Elateridae one day's collecting at Wilmington furnished 31 specimens, another at Council 21, and a third at Fayetteville 28. Of these there were 22 *Melanotus communis* taken at Wilmington, 15 at Council, and one at Fayetteville. There were only a few specimens of *M. communis* taken elsewhere. Nothing worthy of note is of interest until we come to the Coccinellidae. In this family *Ceratomegilla fuscilabris* turns up with 227 specimens at Raleigh, 56 at Fayetteville, and 43 at Council. *Cycloneda munda* is also well represented by 111 at Raleigh and several elsewhere. It is rather curious that *Hippodamia convergens*, a still commoner species, is only represented by 24 specimens in the whole collection. Nothing further of special interest occurs in the Coleoptera until we reach the Scarabaeidae, where it is worthy of note that some of the largest species of Phyllophaga were found sparingly in the pitchers. The Chrysomelidae were represented by 101 *Cerotoma trifurcata* at Raleigh, 33 *Diabrotica 12-punctata* at Raleigh and 37 at Fayetteville, 40 *Paria canella* taken at Raleigh. Last of all the Curculionidae are represented by scattered specimens of several species but the common little *Geraeus picumnus* shows evidence of liking the pitchers as 179 turned up at Raleigh and 120 at Fayetteville.

In the Trichoptera two specimens of *Neuronia posticata* were collected at Fayetteville, and this happens to be the only caddis fly that comes to sugar.

Coming now to the Lepidoptera the first thing to note is the scarcity of butterflies, none of the large or medium sized species being found. A single specimen of *Neonympha eurylus* taken at Raleigh, and one of *N. sosybius* at Raleigh and another at Fayetteville, and a single unidentified skipper at Raleigh make up the entire list.

Among the moths we found plenty of specimens, about half of them Noctuids, but very few were in good enough condition to determine. The pitcher moth, *Exyra ridingsi*, and its larvae were often found alive in the pitchers.

One of the interesting catches in the Diptera was the Tipuloid, *Ptychoptera rufocincta*, of which one taken at Fayetteville was the only one in our collection. Among the Tipulids quite a number of species were represented of which the following may be mentioned, *Geranomyia rostrata*, 15 at Fayetteville and one at Orton, *Rhipidia domestica*, 10 at Raleigh, and 40 of the tiny *Ormosia innocens* at the same place.

Of the Tabanidae only a few scattered specimens were taken, but two males of *Chrysops* sp., from Fayetteville had uniformly dusky wings and so far remain undetermined. In the Empididae not many were taken, but one from Fayetteville was *Empis poeciloptera* new to the state collection. *Sarcophaga* larvae feeding on the remains of insects were found in nearly every pitcher examined but we had absolutely no success in rearing any. In the Calliphoridae species of *Lucilia* were evidently attracted to the pitchers by the odor of decaying insects; 46 were taken at Raleigh and 30 at Fayetteville.

It is of interest to note that among the Hymenoptera about 80 Ichneumonids were taken at Raleigh, 25 at Fayetteville, and 11 at Council. Most of them were unidentified, but the largest number of

any single species identified was *Ichneumon w-album* of which 11 were taken at Raleigh.

Nothing further of interest occurs until we come to the ants, and the most prominent genus represented was *Crematogaster* which is represented by over 1500 specimens taken at Raleigh and over 1000 each at Council and Wilmington. The number of these can reasonably be accounted for by the fact that a colony was in the vicinity of the pitchers, and the unhappy members were attracted to the pitchers for their destruction. Possibly a thousand other ants were taken at other places. The Psammocharidae were represented by about a dozen species, mainly by only a few specimens each. Of these *Ageniella iridipennis* from Raleigh and *Sericopompilus posticatus* from Council were new records for the state. *Pedinaspis legatus* was represented by two very undersized females from Council and two males each from the same locality and Wilmington. None of the others were of special interest.

Other wasps were represented by scattered examples only and the same may be said of the bees as well.

About 200 spiders were taken, nearly all unidentified, together with a few harvestmen, as well as an occasional snail. It may be noted that the juices of the pitcher plants were capable of dissolving a snail's shell, one of which was partly dissolved.

Two small frogs were taken resting inside the pitchers at Orton, May 2, 1939.

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All the following literature refer to insects *living* in the pitchers, not to those caught by them:

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## BOOK NOTICES

OUTLINES OF ENTOMOLOGY, by A. D. IMMS. Pages vii and 184, 96 figs., 1942. Size  $5\frac{1}{2} \times 8\frac{3}{4}$  inches. Published by E. P. DUTTON AND COMPANY, INC., 300 Fourth Ave., New York City. Price, postpaid, \$3.75.

This handy small volume shows the impress of total war. "This book is produced in complete conformity with the authorized economy standard." "The book is intended for anyone who wishes to acquire an elementary knowledge of entomology as a branch of general zoology. It is written especially for the student embarking upon a university training in zoology or agriculture in preparation for a career. . . . It represents the author's ideas on the fundamentals of the subject and is based upon nearly forty years of experience at home and abroad."

Professor Imms is Reader in Entomology and Fellow of Downing College of Cambridge University. He is late Chief Entomologist of the Rothamsted Experimental Station, known as the premier agricultural experimental station in the world; and he was formerly Forest Zoologist to the Government of India.

The material is arranged as follows: Part I. Introduction, pp. 1-5; II. Anatomy and Physiology, pp. 6-78; III. Embryology, Growth and Metamorphosis, pp. 79-97; IV. Nomenclature and Classification, pp. 98-166; V. Relationships of Insects, pp. 167-176; Index, pp. 177-184.

There is no padding in *Outlines of Entomology*. It is the most condensed statement of the many and very diverse forms of insect structure, function and habits which we have seen. The illustrations are well chosen, large enough to be comfortable to the eye of the reader and are well labeled. It is an extreme condensation of the type of material Imms used in "A General Textbook of Entomology," and in the two editions of "Recent Advances in Entomology.—C. H. K.

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SYSTEMATICS AND THE ORIGIN OF SPECIES, by ERNST MAYR, 1942. Pages xiv and 334, 14 tables, 29 text figures. Size  $9\frac{1}{4} \times 6$  inches. Published by the COLUMBIA UNIVERSITY PRESS, 2960 Broadway, New York City. Price \$4.00, postpaid.

From the author's Preface: "During the past fifty years animal taxonomy has undergone a revolution almost as fundamental as that which occurred in genetics after the rediscovery of Mendel's laws. The change from the static species concept of Linnaeus to the dynamic species concept of the modern systematist has not entirely escaped the attention of progressive students of genetics and evolution. However, the significance of polytypic species, of the phenomena of geographic and other forms of isolation are by no means as widely appreciated among students of evolution and even among taxonomists as they deserve."

"Dr. Mayr is an outstanding systematist; his specialty is ornithology, and he is the foremost authority on the birds of Oceania and Indonesia" (Th. Dobzhansky). The latter is an entomologist who finally entered the genetics laboratory and dragged *Drosophila* into the field where its many species live under natural conditions. He states further: "Dr. Mayr's chief accomplishment in this book has been to correlate the evidence and the points of view of modern systematics with those of other biological disciplines, particularly genetics and ecology."

The volume is devoted entirely to a discussion of the present day species concept, an evolving population rather than a static finally describable form. His shorter definition is: "Species are groups of actually or potentially interbreeding natural populations which are reproductively isolated from such other groups." He covers the following topics: I. Methods and Principles of Systematics; II. Taxonomic Characters and Their Variation; III. Geographic Variation; IV. Some Aspects of Geographic Variation; V. Systematic Categories and the New Species Concept; VI. Polytypic Species; VII. Species in Evolution; VIII. Nongeographic Speciation; IX. Biology of Speciation; X. Higher Categories and Evolution.

The work is very closely documented and with a sixteen page bibliography, *with titles*. He has few kind words for the systematist whose whole ambition is to

perpetuate his name on another new species, and his comments on "aberrations"! By definition of "aberration" all individuals of *Homo sapiens*, each and all, are aberrations. Why not describe them and name them? He recognizes the almost unbelievably great task facing taxonomists in entomology with a million or more unnamed species to be studied and defined. He comforts us by pointing out that the only way we can dig out is to use the earlier concept of static or near static species until that time when distributions and interrelationships are known in more detail. Entomologists will still have to rely on experience, judgment and hard work.

Mayr is one of the men in charge of the great Lord Rothschild collection of birds recently purchased by the American Museum of Natural History which, with the Museum's own collection of North and South American birds, makes that institution's collection the greatest in the world. The distribution, speciation and interrelationships of birds are better known than those of any group of animals unless those of Lepidoptera. Dr. Mayr knows bird species and species distribution. He is in a position to write with authority.—C. H. K.

ON THE PREPARATION AND PRESERVATION OF INSECTS, with particular Reference to Coleoptera, by J. MANSON VALENTINE. Pages 1-16, 1942. Published in Smithsonian Miscellaneous Collections, Vol. 103, No. 4.

The ANNALS has little space for notice of items of sixteen pages. But, the present high quality of well illustrated taxonomic articles offered to the ANNALS has come from no editorial policy or ruling but from the steady development of taxonomic technique. All species that can be so described are differentiated on genitalia, usually those of the male but at times those also of the female. These characters appear to be good in a great many groups. However they fail in a few. In our common ants with physiological (social) species genitalic characters for species determination are of little value. In many non-social forms of Hymenoptera the remarkable work of such as that of Murray on *Sphex* has shown the necessity of a minute study of genitalia. Only a first class technique of preparation and first class drawings of genitalia can give us the full advantage of our increasing knowledge in taxonomic entomology. How many times have we heard: "One good figure is equal to two pages of text," in the exact determination of a new species (or the correct placement of an "old" species).

This pamphlet gives us an exacting and powerful technique for the study of small beetle species. It has been written with wide advice from the experts in Federal taxonomic work on beetles.—C. H. K.

STRAIGHT AND CROOKED THINKING, by ROBERT H. THONLESS, 284 pages. 1930. 4½x6½ inches. Published by HODDER AND STOUGHTON, LTD., London.

Few books have interested us in recent reading as has this pocket volume. We are calling the attention of all those who wish to guard against certain types of faulty reasoning in their own expository writing. Those who will enjoy it most are the reader-critics whose greatest pleasure is found in the faulty thinking of others. If Thonless' volume were required in deliberative (?) bodies of politicians as is Robert's "Rules of Order" it would wreck much political argument from city councils and police courts to Congress and the League of Nations. The book is ammunition in a parlor discussion but is veritable castor oil to the rabble raiser. All individuals who act on the assumption that they can think will enjoy *Straight and Crooked Thinking*. The volume is a masterpiece of lucid exposition.

Contents: Emotional Meanings; All and Some; Dishonest Tricks in Argument; Logical Fallacies; Tricks of Suggestion; Habits of Thought; Tabloid Thinking; Pitfalls in Analogy; On Drawing the Line; Vagueness; Prejudice; Need for *Straight Thinking*.

Appendix: Thirty-four Dishonest Tricks; A Discussion Illustrating Crooked Thinking.—C. H. K.



**INTRODUCTION TO APPLIED ENTOMOLOGY**, by WILLIAM J. BAERG. Pages i-vii plus 1-146. 128 figures. 1942. Second edition, Published by BURGESS PUBLISHING COMPANY, Minneapolis, Minn. Price \$2.25.

This new edition is a great improvement over the first edition which appeared under the title "Introduction to Economic Entomology" in 1937.

Many parts of the book have been almost entirely re-written. The latest control measures and life history data have been incorporated under the discussions of each pest. The pests are taken up from the classification or systematic viewpoint. The addition of 128 original illustrations is also a very great improvement over the first edition. These appear in most cases to have been well done.

As in the first edition only the most important pests are considered and special emphasis is given to those which are problems of the southern United States. The other classes of Arthropods which have some economic bearing on man are treated prior to the sections on insect morphology, metamorphosis, and artificial control. A discussion of all the natural controls, in my opinion, would be a valuable addition. Following the discussion of each pest or group of pests, a selected list of references is given. This volume has also the addition of an index.

With all of these improvements, a wider use of this text appears to be definitely assured.—R. H. DAVIDSON.

**INTRODUCTION TO PARASITOLOGY**, by A. S. PEARSE. ix+357 pages; 448 illustrations. C. C. THOMAS, Springfield, Ill. 1942. Price \$3.75.

This new book of animal parasitology is a brief account of those members of the animal kingdom that live in or on other animals. Therefore, the parasitic fauna of man and the domestic animals is not emphasized and it is pleasing to see the large amount of information that could be included only in a book written from the purely zoological point of view. In addition to protozoa, worms, and arthropods, which are the stock and trade of the parasitologist, there are excellent accounts of parasitic and consortic mesozoans, sponges, coelenterates, ctenophores, rotifers, annelids, molluscs, and chordates.

One-third of this volume is about arthropods. Insects, including those used in the biological control of insect pests, receive generous treatment. For general reading and for students of entomology, zoology, and wildlife conservation this book can be whole-heartedly recommended. Some excellent features are the simplicity and concreteness of presentation; chapters on methods, and numerous uniform and excellent illustrations which are taken from original sources.

—C. E. VENARD.

**ON GROWTH AND FORM**, by D'ARCY WENTWORTH THOMPSON, New Edition, 1942. Pages 1-1116, 554 text figs., 2 pls. and many tables.  $5\frac{3}{4} \times 8\frac{3}{4}$  inches. Published by the CAMBRIDGE UNIVERSITY PRESS (Cambridge, Eng.) and THE MACMILLAN COMPANY, 60 Fifth Ave., New York City. Price \$12.50.

The first edition of *Growth and Form* appeared in 1917. The author, Sir D'Arcy Thompson, Professor of Natural History at Saint Andrews University, Dundee, Scotland, has been an international figure on various British and International Commissions that sat on marine fisheries problems. He was Lowell Lecturer at Harvard in 1936 and is a member of the most famous of all clubs of distinguished intellectuals, The Athenium of London.

Since Darwin's assumption of a tight fit of animal form in its environment as a matter of survival, biologists have been more or less interested in the problem of form. How did the animal acquire its form? Why might a whole genus of organisms all in nearly equal environments show a variety of distinct forms? Why do we find the startling change in form from seed to flowering form of many plants which do not shift environments as the plant form changes?

Thompson starts with cells, the building blocks of which living forms are constructed. He points out their physical limitations and the limitations of form imposed by the limitations of the material. His volume is a detailed discussion of organic form from the point of view of the physicist. He employs their formulae of stresses, strains, limits and space relationships.

Unfortunately the majority of biologists are raised on studies of function. They enter a life study of biology from organic chemistry, physiology and bi-mathematics which are the most useful tools in their particular fields. Unfor-

unately for such education, form and function are indissolubly integrated. In life one cannot exist without the other. The chemists have come to recognize this great gap in chemical studies. They have developed physical-chemistry which by the morphology of molecules helps explain crystals, elasticity and colloidal phenomena and other specific chemical activity. The biologists have found function such a complex and profitable field the majority have not taken time to use even simple physical theory and techniques.

Because the field of physical biology has been so neglected the research on its problems is widely scattered and much is buried in physical literature. We recall many articles on vision in optical journals, on form in physical publications. Thompson has brought these opening studies together and has amassed data in a convincing argument that here we have a bio-physical field scarcely known at present and from the scattered facts and immature techniques used, a vast field which is yet in its infancy.

Some of the topics: Magnitude; Rate of Growth; Internal Form and Structure of the Cell; Adsorption; Forms of Tissues; Concretions, Spicules; The Equiangular Spiral; Shapes of Horns, Teeth, with a Note on Torsion; Leaf Arrangement; Shapes of Eggs; Form and Mechanical Efficiency; Theory of Transformations or the Comparison of Related Forms.

On Growth and Form is a masterly review of a rich but almost unexplored field of biology which touches taxonomy, species distinctions, embryology, adaptation to environment and other basic biological problems, on a study of the details of which entomologists make their living and taxes.

On another page of these Annals is noticed the recent work by Joseph Needham, the British embryologist and organic chemist. We glory in the thought that our country has as an ally a country whose great universities can produce such additions to and summaries of knowledge while under pressure of a total war.

—C. H. K.

**GUIDE TO THE LITERATURE OF THE ZOOLOGICAL SCIENCES**, by ROGER C. SMITH, pages vii and 123, 1942. Mimeograph, cartridge paper covers,  $8\frac{1}{2} \times 10\frac{3}{4}$  inches. Published by BURGESS PUBLISHING Co., 426 South Sixth St., Minneapolis, Minn. Price, \$2.00.

The present guide covers zoological literature because of which wide coverage it is not as detailed for the field of entomological literature as many entomologists might desire. For the very same reason it will be of more value to the entomologist in the exploration of borderline fields than would be a more strictly limited entomological guide. With several good review journals in the field of entomology as well as a good guide to literature, Professor Smith was wise in choosing the field he has covered. Further, the volume will be of wide use among zoologists.

The eight chapters are: I. Mechanics of the Library; II. Bibliographies of the Zoological Sciences; III. Abstract Journals; IV. The Form of Bibliographies; V. The Forms of Literature; VI. Preparation of a Scientific Paper; VII. Taxonomic Indexes and Literature; VIII. Library Assignments.

On page 94 under an inconspicuous subtitle are given the basic assumptions on which the work is based; the subtitle reads "Reasons for Writing Scientific Papers." The first three given are: "a. To record results of scientific research; b. To establish priority on a phase of the subject; c. To report on a phase of a problem to assist other workers in the same field." We would have placed item "c" first and have discarded the other five items. The reviewer teaches a similar course and teaches that scientific writing to be good and of real value must be for the reader. In editorial work we sometimes suspect authors of writing to advertise. Usually an article by such shows a selfconsciousness which detracts from its effectiveness as a building stone in the edifice of science. Too often such a point of view leads the scientific man to shallow, hasty work and superficial exposition. He jumps forward to another title listed in his bibliography. He overlooks and leaves sound methods behind him.

On the bottom of the same page (94) the author himself, in subheads (3) and (4) on how to compose a title, develops the point of view that writing is for the reader.

Chapter VIII, Library Assignments, will help some teachers. We prefer to have the student actually write a publishable paper, one which requires consid-

erable library work. To get the habit of productivity the student must be put on his own. We do not approve of professor-student authorship. The student should be in position to take full pride in his own accomplishment. If he does, he may repeat the experiences of being personally productive. The professor's duty is to guide, not give too much and certainly not to take from the developing ego of the beginner. One has to take pride in his work to keep it up to perfection, and has to learn the pleasure to himself from bestowing pleasure on others in his field.

The lack of "banner" page heads reduces ease of use but even more does the lack of space for the chapter heads and major chapter subheads. Each of the many subheads looks too much like the others for the eye to pick up the important, guiding major heads. A few additional pages to spread the format would have made a work much more usable. Print format cannot be condensed except to the disadvantage of the reader; remember, we are writing for the comfort of the reader.

We do like the historical notes so freely given when listing famous journals. The history of our science is slipping by all too much unrecorded. Professor Smith has given us a volume that will be of repeated use in every biological library and in every productive biological laboratory.—C. H. K.

BIOLOGICAL SYMPOSIA, VOL. VIII. Levels of Integration in Biological and Social Systems, (articles by twelve authorities). Edited by JACQUES CATTELL, 1942. Pages 1-240. 7x10 inches. Published by THE JACQUES CATTELL PRESS, Lancaster, Penna.

The papers included in this volume form a symposium held in September, 1941, in connection with the celebration at the University of Chicago of the fiftieth anniversary of the University.

We have among insects some of the most amazing and highly evolved societies known to man. With these we find a great series of "semisocial" insects in all degrees of social development. This area of entomology is one of the richest fields for the study of the elemental factors and relationships of animals to each other when the species passes into a social organization.

The problems of integration in biological systems from colonial Protozoa to man are discussed in eleven elaborate papers and from several points of view. Professor Thomas Park discusses Integration in Infra-Social Insect Populations. Professor A. E. Emerson discusses Basic Comparisons of Human and Insect Societies.—C. H. K.

THE GENUS *CONOTRACHELUS* DEJEAN (COLEOPTERA, CURCULIONIDAE) IN THE NORTH CENTRAL UNITED STATES, by HERBERT FREDERICK SCHOOF. Illinois Biological Monographs, Vol. 19, No. 3, pp. 1-170, 9 plates, 1942. The UNIVERSITY OF ILLINOIS PRESS, Urbana, Ill. Price \$1.50.

This is a monograph of the 28 species of *Conotrachelus* now known to occur in the states of Illinois, Wisconsin, Iowa, Missouri, Kentucky and Indiana. Five of these forms are new to science. The description of a new species not known to occur in the area is presented as an addendum. Keys are given for four groups which have been reduced from six, as well as keys to the species.

Importance of morphological structures is evaluated, including a detailed account of the male genitalia of *C. nenuphar* (Hbst.). Uncus, mesoscutellum and metasternal grooves are used as characters.

A detailed account of methods used in removal, study and preservation of male genitalia is given. The author uses the terms lectotype, lectoparatype, neotype, neoallotype, neoparatype and plesiotype.

This paper should be a considerable aid in identification of the members of this genus occurring in the upper Mississippi region.—J. N. KNULL.

**THE MUSCULATURE OF THE LABRUM, LABIUM AND PHARYNGEAL REGION OF ADULT AND IMMATURE COLEOPTERA**, by CARL KESTER DORSEY, pages 1-42, 24 pls. with 134 figs. 1943. Published as Vol. 103, No. 7, of Smithsonian Miscellaneous Collections, Smithsonian Institution, Washington, D. C.

The object of this study was to determine how a chewing insect handled food in its cibarium and particularly how it brought food to the true mouth at the anterior end of the pharynx. The work was done at the University of Maryland under the supervision of Professors Snodgrass and Cory. The many illustrations are well drawn so that they explain the text in a clear manner. Twenty-two families are represented in the study. In each case larva and adult had been carefully identified as of the same species by the taxonomists of the Bureau of Entomology and Plant Quarantine. Thus the work bears the checks and imprint of high authority.—C. H. K.

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**FIELDBOOK OF NATIVE ILLINOIS SHRUBS**, by LEO R. TEHON. Manual 3. 1942. Pages 1-307, 172 figs., map and 4 col. pls.,  $4\frac{1}{2} \times 7\frac{1}{2}$  inches, hard cloth bound. Published by ILLINOIS NATURAL HISTORY SURVEY, Urbana, Illinois. Price, postpaid, \$1.25.

This pocket manual keys out, describes and states distribution of 210 species and 27 varieties of shrubby plants found in Illinois. One-hundred-seventy-two of them are figured in black and white and six in colors.

The descriptions are in simple terms for which there is a glossary. The use of the books implies a small knowledge of plant anatomy.

Doctor Tehon has been in charge of the Survey's Section of Applied Botany since 1922. Adapting the material to the format of the Survey's manual series was the work of James S. Ayars, Technical Editor. The excellent line drawings are by Miss Kathryn M. Sommerman. The colored photographs are by Ray H. Hamm, University of Illinois photographer, by Dr. Tehon and by Editor Ayars.

The beautiful illustrations make the manual of use to the general public. The keys are very simple but are still probably beyond the patience of the casual user. The problem is that we have too many plants.—C. H. K.

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**THE TALE OF THE PROMETHEA MOTH**, by HENRY B. KANE. About 40 pages (not numbered), 7x9 inches. 1942. Published by ALFRED A. KNOPP, New York. Price, \$1.50.

This little book is the third in the series of children's books, "Wild World Tales," "factual stories of our native wild life told in a manner calculated to entertain while they instruct." It tells in simple language the life-history of the Promethea moth, and is illustrated with 24 full-page photographs and many pen-and-ink sketches by the author. The account is clear and accurate, and the illustrations are unusually good.

This is the sort of book which we would recommend to entomologists who would like their children to become interested in insects. Our eight-year old son read it in one sitting, with evident enjoyment.—D. J. B.

# MEMBERS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA ENROLLED IN THE ARMED AND RELATED SERVICE OF THE UNITED STATES<sup>1</sup>

- ARCHER, SGT. A. F., Sanitary Technicians' School, Camp Grant, Ill.
- BABERS, MAJ. FRANK H., Hdq. 39th C. A. Brig. A. A., Seattle, Wash.
- BARNETT, SGT. HERBERT C., Division of Parasitology and Tropical Medicine, Army Medical School, Army Medical Center, Washington, D. C.
- BARRETT, PVT. PAUL H., Med. Det., Percy Jones General Hospital, Battle Creek, Mich.
- BARRETT, W. L., JR.
- BELKIN, 1ST LT. JOHN N., Sn. C., M. D. R. P., M. R. T. C., Camp Joseph T. Robinson, Ark.
- BENTON, CURTIS, Med. Corps.
- BERTAGNOLLI, 2ND LT. ALFRED A., 877 Chemical Company, Barksdale Field, La.
- BILLINGS, LT. S. C., Norfolk Army Base, H. R. P. E., Norfolk, Va.
- BLANTON, LT. F. S., Sn. C., Fort Robinson, Ark.
- BOHART, ENSIGN R. M., U. S. N. R., Malaria Control Lab., Hadnot Point, New River, N. C.
- BROWN, CAPTAIN F. MARTIN, Colorado Springs, Colo.
- BUNN, MAJ. RALPH W., 1st Medical General Laboratory, Fort Sam Houston, Tex.
- BURKS, 1ST LT. B. D., Sn. C., Camp Van Donn, Centerville, Miss.
- BUZICKY, 2ND LT. ALFRED.
- CHAMBERLAIN, PVT. ROY W., Med. Det. S. C. U. 1968, Reception Center, U. S. Army, Fort Douglas, Utah.
- CHRISTENSON, L. D., 3rd Malaria Survey Unit, New Orleans Staging Area, New Orleans, La.
- CONNELL, 1ST LT. WM., Medical Section, 1580 S. U., Camp Campbell, Ky.
- COPE, ENSIGN OLIVER B., Malaria Control, Marine Corps Air Station, Cherry Point, N. C.
- CURTISS, LT. CHARLES.
- DAGGY, ENSIGN RICHARD H., (M. C.) U. S. N. R., M Division, Navy 212, Fleet Post Office, San Francisco, Calif.
- DAHM, PAUL A.
- DANIEL, DERRILL M.
- DELEON, PVT. DONALD, Co. B, 103 Bn., M. R. T. C., Camp Robinson, Little Rock, Ark.
- DENNING, DONALD G., U. S. P. H. S. (R), 207 Civil Courts Bldg., New Orleans, La.
- DODGE, H. RODNEY, U. S. P. H. S., Box 1095, Macon, Ga.
- DORSEY, ENSIGN CARL K., U. S. N. R., Naval Medical School, Bethesda, Md.
- DORST, MAJ. HOWARD E., Hq. M. R. T. C., Camp Robinson, Ark.
- DOW, LT. RICHARD, Sn. C., Station Hospital, Camp Cooke, Calif.
- EATON, PVT. CHARLES B., 615th T. S. S. (sp.), B. T. C. (5) A. F. F. T. T. C., Kearns, Utah.
- ELISHWITZ, HAROLD, Med. Res. Inst., National Naval Med. Cen., Bethesda, Md.
- EMERSON, LT. K. C., Fort William McKinley, Rizal, P. I. (Reported missing. Probably prisoner of Japanese.)
- FISHER, ELIZABETH, American Red Cross, Washington, D. C.
- FISK, CAPT. FRANK W., Med. Sec., S. O. S., A. P. O. 886, care of Postmaster, New York, N. Y.

<sup>1</sup>A list of all entomologists, whether members of any entomological society or not, enrolled in the Armed and Related Services of the United States, will be published in an early issue of the *Journal of Economic Entomology*.

FREEBORN, LIEUT.-COL. S. B., Sr. Surgeon, Malaria Control in War Areas, 508 Volunteer Bldg., Atlanta, Ga.

FRONK, 2ND LT. W. DON, School Dept., Fitzsimmons Hospital, Denver, Colo.

GILGOLLY, PVT. LORIN R., Hdq. 80th Inf. Tng. Bn., Camp Roberts, Calif.

GRESSITT, J. LINSLEY, Prisoner of Japanese at Canton, China.

GURNEY, 1ST LT. ASHLEY B., Station Hospital, Camp Crowder, Mo.

HALL, DAVID G.

HARDEN, PHILIP, U. S. P. H. S. (R), 207 Civil Courts Bldg., New Orleans, La.

HART, LT. THOMAS A., Station Hospital, Camp Gordon, Georgia.

HARDY, CAPT. ELMO D., A. P. O. 629, c/o Postmaster, Miami Fla.

HAUG, LT. GORDON W., 1st Bn., Rocky Mountain Rangers, Colwood Camp, Victoria, B. C.

HEATON, 1ST LT. ROBERT R., M. D. R. P., Billings General Hospital, Fort Harrison, Ind.

HERMS, LT. COL. W. B., Army Medical Field Service School, Carlisle Barracks, Pa.

HITCHCOCK, PVT. F. C. JOHN D., 4th Platoon, 300th General Hospital, Camp Forrest, Tenn.

HOFFMAN, WM. E., Prisoner of Japanese at Canton, China.

HOLWAY, ENSIGN RICHARD T., U. S. N. R., Naval Medical Center, Bethesda, Md.

HORSFALL, 1ST LT. WM. R., Sn. C., Camp Grant, Ill.

HURLBUT, LT. HERBERT S., H-V (S), U. S. N. R., Box 36, N. O. B., Guantanamo, Cuba.

HUTCHINS, LT. (J. G.) ROSS E.

JONES, JR., CADET JOSEPH W., A. A. C., P. O. Box 173, Newbern, Tenn.

KECK, CAPT. C. B., A. U. S., Box 340, Honolulu, T. H.

KENT, ELLIS C.

KING, LT.-COL. W. V., Laboratory Fourth Service Command, Fort McPherson, Ga.

KLOTS, CAPT. ALEXANDER, B., Sn. C., Camp Robinson, Ark.

KNIGHT, ENSIGN KENNETH L., (M. C.), U. S. N. R., A. P. O. 932, care of Postmaster, San Francisco, Calif.

KNIGIN, TAMARATH, Malaria Laboratory, Office of Sector Surgeon, A. P. O. 868, care of Postmaster, New York, N. Y.

KRAFCHECK, PVT. BERNARD, General Hospital, Fort Dix, N. J.

KRAMER, CORP. SOL, M. D. P. S. S., Army Medical School, Washington, D. C.

KRETZSCHMAR, ENSIGN G., District Coast Guard Office, 310 N. Washington Square, Philadelphia, Pa.

KROMBEIN, LT. KARL V., 1318th Service Unit, Post Headquarters, Camp Pickett, Va.

KUITERT, LT. LOUIS C., Sn. C., Army Air Base, Dyersburg, Tenn.

LANHAM, PVT. URLESS N., 4th Mapping Squadron, March Field, Riverside, Calif.

LIVINGSTON, 1ST LT., E. M., Sn. C., Camp Pickett, Va.

LOWRIE, RAYMOND E.

LUND, LT. (J. G.) HORACE O., Naval Air Station, Elizabeth City, N. C.

MACCREARY, LT. (J. G.) DONALD, H-V (S), U. S. N. R., Newark, Del.

MANGRUM, PVT. JAMES F., 183 General Hospital, Fort Sill, Okla.

MANZELLI, 1ST LT. MANLIO, Sn. C., Station Hospital, Camp Carrabelle, Fla.

MARCH, 2ND LT. RALPH B., IV Ground Air Support Command, Presidio, San Francisco, Calif.

MASON, LT. COL. HORATIO C., Academic Dept., Infantry School, Ft. Benning, Ga.

MEDLER, ENSIGN, JOHN T., H-V (S), U. S. N. R., Yard Dispensary, Mare Island, Calif.

MILLIRON, 1ST LT. HERBERT E., Sn. C., 1560th Service Unit, Medical Section, Station Hospital, Camp Atterbury, Ind.

MUNDELL, R. C. (deceased 1942, while a member of fighting forces in India.)

MUNSON, SAM C.

- NICHOLSON, H. PAGE, U. S. P. H. S. (R), 300 Essex Bldg., Norfolk, Va.  
 NYE, CAPT. W. P., U. S. Marine Corps, Camp Pendleton, Oceanside, Calif.
- OMAN, LT. P. W., Sn. C., Carlisle Medical Center, Carlisle, Pa.  
 OWEN, CAPT. WM. B., Carlisle Barracks, Pa.
- PARSONS, CORP. CARL T., Medical Detachment, Hendricks Field, Sebring, Fla.  
 PEDERSON, LT. (J. G.) CALVIN E., H-V (S), U. S. N. R., Malaria Control Laboratory, U. S. Naval Air Station, Trinidad, B. W. I.  
 PETERS, 1ST LT. HAROLD T., Station Hospital, Camp Pickett, Va.  
 PETERSON, ALLAN, U. S. P. H. S. (R), State Board of Health, Jackson, Miss.  
 PETTIT, LINCOLN C.  
 POST, R. L., Coast Guard, A. S. (R. R.), Bonneville, Ore.  
 PRATT, HARRY D., U. S. P. H. S., San Juan, Puerto Rico.  
 PRITCHARD, A. EARL, Base Hospital, A. P. O. 848, New York, N. Y.
- REED, LT. W. D., Service Division, Edgewood Arsenal, Md.  
 RICHMOND, MAJ. E. A., Technical Division, C. W. S., Bldg. 330, Edgewood Arsenal, Md.  
 RIEGEL, 1ST LT. GARLAND T., Sn. C., Post Surgeon's Office, Ft. Leonard Wood, Mo.  
 RINGS, PVT. ROY W., Headquarters Reception Center, Ft. Benjamin Harrison, Ind.  
 ROBERTS, CAPT. R. A., Sn. C., Army Officers Tn. Bn., Carlisle Barracks, Pa.  
 ROCKSTEIN, CPL. MORRIS, Base Weather Office, Bradley Field, Conn.  
 ROSS, LT. E. S., Sn. C., 8th Service Command Laboratory, Ft. Sam Houston, Tex.  
 ROTH, LOUIS M., Laboratory, 4th Corps Area, Ft. McPherson, Ga.  
 RYAN, PVT. GEORGE S., Btry. C-399 CA, B. B. Bn., Sault Ste. Marie, Mich.
- SCHROEDER, CAPT. PHILLIP C., R. O. T. C., University of Minnesota, Minneapolis, Minn.  
 SHIELDS, LT. S. E., Sn. C., Key West Barracks, Fla.  
 SMITH, GORDON E., A. P. O. 885, c/o Postmaster, Port of Embarkation, New York, N. Y.
- SPENCER, MAJ. HERBERT, Sn. C., Station Hospital, Camp Shelby, Miss.  
 SPIETH, 1ST LT. HERMAN T., A. C. Roney Plaza, Miami Beach, Fla.  
 STAINS, ENSIGN GEORGE S., District Medical Office, 14th Naval District, Pearl Harbor, T. H.  
 STEARNS, MAJ. L. A., Sn. C., Hq. Ninth Air Force, Bolling Field, D. C.  
 STONE, 1ST LT. PHILIP C., Sn. C., Carlisle Barracks, Pa.  
 STRICKLAND, E. H., No. 133, Can. Army Basic Tn. Cen., Prince of Wales Armory, Edmonton, Alberta, Can.
- TARSHIS, IRVIN.  
 THATCHER, CAPT. T. O. (0-305-165), Hq. 495 C. A. & Br. (A. A.), A. P. O. 860, care of Postmaster, New York, N. Y.  
 TRAUB, 1ST LT. ROBERT, Sn. C., 9th Malaria Survey Unit, New Orleans Staging Area, New Orleans, La.  
 TUCK, PVT. J. B., O. C. P. S., Det. M. R. T. C., Company B, Camp Barkeley, Tex.  
 TULLOCH, GEO. S.
- WALLACE, CORP. GEO. E., Co. K, ER 8, Enlisted Students Bn., Student Rgt. T. D. School, Camp Hood, Tex.  
 WENZEL, 1ST LT. R. L., Sn. C., 707th Med. Sn. Co., Ft. George G. Mead, Md.  
 WEST, 2ND LT. WM. R., 14th R. O. C., M. C. S., Co. B, Barracks B, Quantico, Va.  
 WILSON, LT. JOHN W., M. C., Wellston Air Depot, Macon, Ga.  
 WOKE, LT. PAUL A., U. S. N. R., Navy 213, care of F. P. O., New York, N. Y.  
 WORTHELEY, MAJ. H. N., C. W. S., R. T. C., Camp Sibert, Ala.

# THE ENTOMOLOGICAL SOCIETY OF AMERICA

## REPORT OF THE THIRTY-SEVENTH ANNUAL MEETING

New York, New York, December 29-31, 1942

The Thirty-seventh Annual Meeting of the Entomological Society of America was cancelled on December 7, 1942, with the approval of the Executive Committee and at the request of the Office of Defense Transportation, United States Government. Arrangements for the meeting were practically completed and the program was in press at the time of cancellation. This is the first time since its organization that the Society has not held its Annual Meeting.

The program which had been arranged for the three-day meeting at the Hotel New Yorker follows:

### Opening Session, Tuesday Morning, December 29

1. A Revision of the Nearctic Gnats of the Tribe Tendipedini (=Chironomini). (15 min.) H. K. TOWNES, Bureau of Entomology and Plant Quarantine, Washington, D. C.
  2. The Internal Genitalia and Mating Behavior of *Eurukuttarus confederata* Grote. (8 min., Lantern.) JOSEPH L. WILLIAMS, Lincoln University, Pennsylvania.
  3. The Male Reproductive System of the Carpenter Ant, *Camponotus herculeanus pennsylvanicus* De Geer (Formicidae: Hymenoptera). (15 min., Lantern.) JAMES FORBES, Fordham University, New York, N. Y.
  4. Some Vitamin Requirements of Black Carpet Beetles, *Attagenus* sps. (5 min.) WARREN MOORE, Bon Air, Virginia.
  5. Intrapuparial Phases of *Rhagoletis pomonella* Walsh. (10 min., Lantern.) R. W. DEAN, New York State Agricultural Experiment Station, Poughkeepsie, New York.
  6. The Ecology, Seasonal History, and Relative Prevalence of Mosquitoes of the Great Swamp in Rhode Island during 1942. (10 min., Lantern, 3¼x4; 2x2.) HERBERT KNUTSON, Rhode Island State College, Kingston, Rhode Island.
- 11:55 A. M.—Adjourn to Grand Ball Room, Hotel New Yorker, to meet with the American Association of Economic Entomologists to hear the address of their president.

### Second Session, Tuesday Afternoon, December 29

JOINT SESSION WITH AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

#### SYMPOSIUM

##### "Entomology and the War"

- Entomological Problems Imposed by War Conditions. (25 min.) P. N. ANNAND, Bureau of Entomology and Plant Quarantine, Washington, D. C.
- Entomology and Malaria Control in War Areas. (13 min.) L. L. WILLIAMS, JR., U. S. Public Health Service, Atlanta, Georgia.
- Some Entomological Aspects of Troop Mobilization. (13 min.) LIEUTENANT-COLONEL W. V. KING, Sn. C., Atlanta, Georgia.
- Entomology and Food Mobilization. (25 min.) W. P. FLINT, Illinois Natural History Survey, Urbana, Illinois.
- Agricultural Insecticides in Relation to Critical War Materials. (25 min.) R. C. ROARK, Bureau of Entomology and Plant Quarantine, Washington, D. C.
- Taxonomy and the War. (25 min.) C. F. W. MUESEBECK, Bureau of Entomology and Plant Quarantine, Washington, D. C.
- Training Entomologists for Service in the Armed Forces. (25 min.) C. L. METCALF, University of Illinois, Urbana, Illinois.



**Third Session, Tuesday Evening, December 29**

**ANNUAL PUBLIC ADDRESS**

"The Earliest Insects." DR. F. M. CARPENTER, Harvard University, Cambridge, Massachusetts.

**Fourth Session, Wednesday Morning, December 30**

7. The Entomological Applications of Fluorescence Microscopy. (10 min., Lantern, 2x2.) ROBERT L. METCALF and ROBERT L. PATTON, Cornell University, Ithaca, New York.
8. A New Relationship of the Bursa Copulatrix to the Female Reproductive System in Lepidoptera. (5 min., Lantern.) JOSEPH L. WILLIAMS, Lincoln University, Pennsylvania.
9. A Catalogue and Reclassification of the Nearctic Ichneumonidae. (20 min.) H. K. TOWNES, Bureau of Entomology and Plant Quarantine, Washington, D. C.
10. Effect of Potassium Fluoride and Pyrethrum on *Periplaneta americana* L. with Chinese Ink Blocked Hemocytes or Trypan Blue Stained Nephrocytes. (15 min.) E. R. MCGOVAN, J. FRANKLIN YEAGER, E. L. MAYER and SAM C. MUNSON, Bureau of Entomology and Plant Quarantine, Beltsville, Maryland.
11. Excavation and Closure of the Nest by "Ammophila" and some other Digger Wasps, with a Demonstration of "Slow-motion" Pictures, Illustrating the Wasps' Behavior. (15 min., 16 mm. Motion Pictures.) C. T. BRUES, Harvard University, Cambridge, Massachusetts. Pictures by Mrs. C. T. BRUES.
12. Selection of Colored Lights by Night-flying Insects. (15 min., Lantern.) LORUS J. MILNE and MARGERY J. MILNE, Randolph-Macon Woman's College, Lynchburg, Virginia, and Johnson Foundation, University of Pennsylvania, Philadelphia, Pennsylvania.
13. Shelter Tree Insects. (12 min.) E. P. FELT, Bartlett Tree Research Laboratories, Stamford Connecticut.
14. The Action of Bean Leaves Against the Bedbug, *Cimex lectularius* L. (10 min., Lantern.) H. H. RICHARDSON, Bureau of Entomology and Plant Quarantine, Washington, D. C.

**Fifth Session, Wednesday Afternoon, December 30**

**TAXONOMISTS' CONFERENCE**

Presiding: C. F. W. MUESEBECK, Bureau of Entomology and Plant Quarantine, Washington, D. C.

Subject: The Species Problem.

**Sixth Session, Thursday Morning, December 31**

15. The Biology and Ecology of the Inhabitants of the Nests of the Prairie Meadow Mouse, *Microtus ochrogaster* (Wagner). (15 min., Lantern.) PHILIP C. STONE, University of Missouri, Columbia, Missouri.
16. Some South American Water Bugs. (10 min., Lantern.) H. B. HUNGERFORD, University of Kansas, Lawrence, Kansas.
17. Lipid Nerve Sheaths in Insects and Their Probable Relations to Insecticide Penetration. (15 min., Lantern.) A. GLENN RICHARDS, JR., University of Pennsylvania, Philadelphia, Pennsylvania.
18. The Role of Nutrition in Sex Determination in the Hymenoptera. (15 min.) STANLEY E. FLANDERS, Citrus Experiment Station, Riverside, California.
19. Histology of the Mouthparts of Larval Ticks (Ixodoidea). (10 min., Lantern, 3 1/4 x 4; 2x2.) HAROLD ELISHEWITZ, University of Minnesota, Minneapolis, Minnesota.

20. Histology of the Metamorphosis of the Mouthparts of Larval Ticks (Ixodoidea). (10 min., Lantern, 3½x4; 2x2.) HAROLD ELISHEWITZ, University of Minnesota, Minneapolis, Minnesota.
21. A Descriptive Study of the Pilotaxy of a Modal *Culex pipiens* Fourth Stage Larva. (By Title.) THOMAS A. HART and J. H. HART, Station Hospital, Camp Gordon, Georgia.
22. Parallel Geographical Variation in Numerous Megachilid Bees. (10 min., Lantern.) CHARLES D. MICHENER, American Museum of Natural History, New York, N. Y.
23. Qualitative Versus Quantitative Analysis in Systematics. (15 min.) MONT A. CAZIER, American Museum of Natural History, New York, N. Y.

The New York Meeting having been cancelled it was impossible to hold the Annual Business Meeting, but the Executive Committee has transacted all urgent business by mail. The reports of the Officers and Committees for 1942 which would have been submitted at the New York Meeting, and the business transacted by the Executive Committee up to February 1, 1943, follows:

#### REPORT OF THE SECRETARY

During the year 1942, the following having been duly nominated and recommended, were elected members of the Society by mail ballot of the Executive Committee:

THEODORE ALLEN, 2520 Mulberry Ave., Muscatine, Iowa.  
THOMAS GLENN BOWERY, 214 Birmingham Ave., Avalon, Pa.  
WILLIAM RICHARD COBB, 1624 Rincon Drive, Whittier, Calif.  
WILLIAM EDGAR CURTIS, Dept. Biology, Cornell University, Ithaca, N. Y.  
ERVIN FREDERICK DAILEY, 7818 Bothell Way, Seattle, Wash.  
THOMAS A. HART, West Georgia College, Genola, Ga.  
CARL GEORGE KADNER, Loyola University, Los Angeles, Calif.  
BERNARD KRAFCHECK, 234 Linden Ave., Ithaca, N. Y.  
JOHN LANE, Instituto de Higiene de São Paulo, Caixa Postal 2.920, São Paulo, Brazil.  
E. MORTON MILLER, Dept. Zoology, University of Miami, Coral Gables, Fla.  
MAYNARD JACK RAMSAY, Dept. Entomology, Cornell University, Ithaca, N. Y.  
FREDERICK JOHN SIMONDS, Imperial Parasite Service, Belleville, Ontario, Canada.  
RUSSELL WM. STRANDTMANN, East Texas State Teachers College, Commerce, Texas.  
VICENTE VELASCO CARRERA, 9a—no. 4-68, Cali, Colombia.  
MINTER JACKSON WESTFALL, JR., Department Entomology, Cornell University, Ithaca, N. Y.

With the approval of the Executive Committee a joint symposium on the subject "Entomology and the War" was arranged with the American Association of Economic Entomologists.

With the approval of the Executive Committee a share of the expenses of PROFESSOR E. O. ESSIG, from Berkeley, California, to Washington, D. C., was paid. PROFESSOR ESSIG is the Society's representative on the Committee for Biology and Agriculture of the National Research Council.

DR. H. T. SPIETH and DR. A. B. KLOTS were appointed by PRESIDENT ALEXANDER to serve on the joint Local Committee for the arrangements of the New York meeting.

With the approval of the Executive Committee DR. F. M. CARPENTER, Harvard University, was invited to give the Annual Public Address at the New York Meeting.

DR. S. A. GRAHAM was appointed by PRESIDENT ALEXANDER as the Society's representative on a joint committee with the American Association of Economic Entomologists for the coordination of entomology with the war effort.

With the approval of the Executive Committee the expenses of DR. S. A. GRAHAM were paid from Ann Arbor, Michigan, to Baltimore, Maryland, to attend a meeting of the Committee for Coordination of Entomology with the War Effort.

The Executive Committee approved the transfer of \$1,000.00 from the Permanent Fund to the Current Funds to provide for publishing the *Annals* with the proviso that \$250.00 be returned from the Current Fund to the Permanent Fund on December 1, 1942, and that \$250.00 be returned from the Current Fund to the Permanent Fund on December 1, 1943, December 1, 1944, and December 1, 1945. Due to a gift from an anonymous donor and to contributions by institutions and individuals towards the publication of papers in the *Annals* it was found not necessary to make this transfer of funds and it now appears likely that no such transfer will be found necessary in 1943.

PRESIDENT ALEXANDER appointed the following as a committee to investigate and report to the Society on the costs of publishing the *Annals*: DR. CLARENCE H. KENNEDY, Chairman; DR. T. H. FRISON and MR. J. R. DE LA TORRE-BUENO.

PRESIDENT ALEXANDER appointed DR. T. H. FRISON to the Thomas Say Foundation Committee to fill out the term of GEORGE P. ENGELHARDT, deceased.

PRESIDENT ALEXANDER appointed the following nominating committee for 1942: DR. H. B. HUNGERFORD, Chairman; DR. WILLIAM A. RILEY and DR. C. T. BRUES.

PRESIDENT ALEXANDER appointed DR. A. L. MELANDER to represent the Society at the inauguration of HARRY NOBLE WRIGHT as the President of the College of the City of New York.

At the request of the Office of Defense Transportation, United States Government, and with the approval of the Executive Committee, the Thirty-Seventh Annual Meeting scheduled for New York, N. Y., December 29-31, 1942, was cancelled.

The Executive Committee has conducted the following business of the Society by mail due to the cancellation of the 1942 Annual Meeting:

The following have been elected to membership in the Society:

EDWARD LAURENCE ATKINS, JR., 708 So. Mathews Ave., Urbana, Ill.

JOHN N. BELKIN, T.V.A. Health and Safety Dept., Wilson Dam, Ala.

JOHN HUGH BROWN, University of Alberta, Edmonton, Alberta, Canada.

HERBERT T. DALMAT, Department of Entomology, Cornell University, Ithaca, N. Y.

JOHN A. FLUNO, 828 W. High St., Jefferson City, Mo.

JAMES T. GRIFFITHS, Department of Entomology, Alabama Polytechnic Institute, Auburn, Ala.

JOHN M. HUTZEL, 21 E. Woodruff Ave., Columbus, Ohio.

RICHARD READE, British Military Hospital, Kingston, Jamaica, B. W. I.

GEORGE S. RYAN, Angola, Indiana.

RAY FRED SMITH, 112 Agri. Hall, University of California, Berkeley, Calif.

THOMAS COBB WATKINS, Comstock Hall, Cornell University, Ithaca, N. Y.

STEPHAN LANE WOOD, Department of Entomology, Utah Agricultural College, Logan, Utah.

The following have resigned during the year: RAIMON L. BEARD, ALFRED A. BERTAGNOLLI, M. H. BRUNSON, HARRY R. BRYSON, DERRILL M. DANIEL, M. H. DONER, CHARLES B. EATON, ROBERT K. FLETCHER, DAVID E. FOX, ORVILLE B. HITCHECOCK, MRS. R. E. HUTCHINS, R. E. HUTCHINS, DONALD L. JACKMAN, ADOLPH KLEIN, URLESS N. LANHAM, DONALD MACCREARY, REV. H. E. MATTINGLY, JAMES A. MULLEN, SAM C. MUNSON, DONALD E. PARKER, L. F. PINKUS, G. H. PLUMB, K. A. SALMON, E. W. E. SCHEAR, L. R. SETTY, ALBERT R. SHADLE, FRED SKOOG, LOUIS A. STEARNS, GEORGE S. TULLOCH, OTTO E. WENGER and DON B. WEFLAN.

The following have been automatically dropped from membership either because of failure for three or more years to pay dues or because they cannot be reached: LEONARD L. HANSEN, J. W. MONK, and MAURICE E. PHILLIPS.

The Society has suffered the loss by death of the following four members during the past year: GEORGE P. ENGELHARDT, CARLOS C. HOFFMANN, ELIZABETH M. MOFFATT, and R. C. MUNDELL.

GEORGE P. ENGELHARDT, a Charter Member of our Society and a Fellow since 1932, was born in Hanover, Germany, on November 23, 1871, and died at Scarsdale, New York, on May 24, 1942. His general activities in biology were many and fruitful. For twelve years he was assistant curator of the Children's Museum in Brooklyn, New York; during eighteen years he was curator of invertebrates in the Brooklyn Museum proper, retiring in 1930 as honorary curator of the department of natural science in that institution. In search of his favorite Aegeriidae and in collecting trips for the Museum he traveled all over North America from Newfoundland and Labrador into Central America as far as Guatemala, and to the Bahama Islands. In these expeditions he invariably remembered his friends and brought them choice specimens from distant and inaccessible places. He was a Fellow of the American Association for the Advancement of Science, a member of the New York Entomological Society and the Brooklyn Entomological Society. He was Treasurer of the latter Society for many years and a most helpful and valuable member of its Publication Committee. His passing is a sad blow to American Entomology, of which he was a most enthusiastic supporter and advocate. In him we have lost also the world authority on the Aegeriidae. It is gratifying to know that his great monograph on this interesting group, which was completed at the time of his death, is to be published before long. He was one of those sterling Americans who by their sincere work honor the land of their birth and add scientific luster to our Republic. He was always an American of enduring loyalty to the land of his free adoption. Yet, current European events caused him great grief. GEORGE P. ENGELHARDT was typical of the best kind of American citizens of German origin. To all of us, his death is the personal loss of a cherished friend, patient with our human foibles and wise in counsel.—J. R. DE LA TORRE-BUENO.

CARLOS C. HOFFMANN, a member of our Society since 1939, was born in Frankfurt, Germany, in 1876, and died in the city of Mexico, November 26, 1942, after a long illness. He arrived in Mexico in 1901 and worked for nineteen years in the Public Health Department as head of the Parasitical Division of the Hygiene Institute, where collaborating with the National University of Mexico, he took part in expeditions to various regions in the Republic in order to study "onchocercosis," and determined the malarial zones of the country as well as the principal transmitters of malaria. He studied the Simuliidae of the onchocercosis region of Chiapas. He organized and took part in campaigns against the locust, malaria and yellow fever. In 1929 he was one of a group of founders of the Biological Institute of the National University, where he worked as head of the Zoological Department and the Section of Entomology. He was professor of Zoology, first in the national Preparatory School, and afterwards in the Science Department of the same University. He was particularly interested in the study of the Arachnida, Diptera and Lepidoptera of Mexico, publishing more than one hundred bulletins about them. In the last three years he limited his field of study and work to the Lepidoptera of Mexico almost exclusively. This resulted in the publication of a Systematic and Zoographical Catalogue from material and observations compiled in the course of the forty years of study of the Mexican Lepidopteran fauna. The Catalogue comprises a critical list of species and forms of the country, bibliographical dates of the original descriptions, synonymy and notes on geographical distribution. He did not live to finish the catalogue as he had planned. Only three parts were published in the *Annals of the Biological Institute of the National University of Mexico*, the Papilionoidea in the first, Hesperioidea in the second and Sphingoidea and Saturnoidea in the third, with a total of 1,542 species. He had all the material ready for a fourth part at the time of his death. He was the first in Mexico to study the formation of races in the "Anopheles Mexicanos." He took part as a representative of the University of Mexico, in expeditions for the study of the poorer regions of the country. This resulted later in improving the living conditions of the inhabitants. He wrote two monographs for the Medical Entomological Society of Mexico with the idea of forming memoirs that could be used by the Mexican physician, hygienist, biologist, or veterinarian. These monographs were: "The Ticks of Mexico" and "The Scorpions of Mexico." The first could not be completely published due to causes beyond his control. Only some few parts were published in the *Annals of the Institute of Biology*. The second monograph was published in the same *Annals* from 1931 to 1939. He was a member of several Scientific Societies, both

Mexican and foreign. He was an outstanding teacher and an indefatigable worker whom death surprised at his post, among his books and collections. Under his direction we had the privilege to study and work in the Section of Entomology.—(MISS) LEONILA VASQUEZ.

ELIZABETH M. MOFFATT, a Life Member of our Society, died in Los Angeles, California, in 1938.

R. C. MUNDELL, a member of our Society since 1930, died in India in 1941 or early 1942. He served for a number of years as an entomologist with the Commonwealth Prickly Pear Board of Australia. Later he was a member of the Division of Economic Entomology of the Council for Scientific and Industrial Research of the Commonwealth of Australia, and had been stationed in India for several years. At the time of his death he was a member of the fighting forces in India.

The total membership on December 31, 1942, is 939.

Article V, Section 3, of the Constitution (*Annals*, Vol. XXIII, p. vi, 1930) provides: "All officers shall be elected by ballot at the Annual Meeting for the term of one year and shall be eligible for re-election." The Executive Committee interprets this to mean that officers cannot be elected by any other procedure and have voted to continue the present officers during the year 1943, since no Annual Meeting was held in December, 1942.

The following were elected by the Executive Committee to the Editorial Board of the *Annals* for the term expiring December 31, 1945: WILLIAM PROCTER, E. M. WALKER and F. M. CARPENTER.

The following were elected by the Executive Committee to the Thomas Say Foundation Committee for the two-year term ending December 31, 1944: T. H. FRISON and C. F. W. MUESEBECK.

The Executive Committee voted to contribute \$100.00 to the Royal Zoological Society of London for the support of the Zoological Record.

Respectfully submitted,

CLARENCE E. MICKEL, *Secretary*.

## REPORT OF THE TREASURER

### CURRENT FUNDS

#### RECEIPTS

Balance on hand in Bank, December 10, 1941 (See <i>Annals</i> , Vol. 35, p. 129) ..	\$1,110.00
From Annual Dues of Members to December 21, 1942 ..	3,414.11
From CLARENCE H. KENNEDY, Managing Editor of <i>Annals</i> ..	1,500.00
From three Life Memberships—NELLIE M. PAYNE, LEONARD D. TUTHILL and ELWOOD C. ZIMMERMAN ..	150.00
From sale of one Membership List ..	1.00
Total ..	\$6,175.11

#### EXPENDITURES

Postage, including 2,000 three-cent stamped envelopes, and 1,400 one and one-half cent stamps ..	\$ 91.52
Spahr and Glenn Printing Co., Columbus, Ohio; printing December, 1941, and March, June and September, 1942, <i>Annals</i> ..	2,990.60
Letterheads for President and Secretary-Treasurer, and stamped envelopes for President ..	17.00
Office Supplies ..	4.40
Printing Preliminary Announcements, Envelopes and Programs ..	80.00
Clerical Services ..	50.40
Contribution to Royal Zoological Society of London for Zoological Record ..	100.80
Travel expenses, Secretary-Treasurer to San Francisco Meeting, and to Urbana, Illinois, for conference with A. A. E. E. Program Committee; E. O. ESSIG to Washington, D. C., for meeting of National Research Council, Section Biology and Agriculture (in part); S. A. GRAHAM	

to Baltimore, Md., for meeting of joint committee on Entomology and the War	233 89
Exchange on checks at Bank	26 25
Telegrams	5 32
Transfer Life Membership Payments to Permanent Fund of NELLIE M PAYNE, LEONARD D. TUTHILL and ELWOOD C. ZIMMERMAN	150 00
Total	\$3,750 18
Balance in Checking Account, December 21, 1942	2,424 93
Total	\$6,175 11

## LIABILITIES

The Society owes the Publishers for the December, 1942, *Annals*. Of the above cash receipts for dues, \$1,384 25 is for 1943 and other dues paid in advance.

## PERMANENT FUND

## RECEIPTS

Balance in Savings Account, December 10, 1941	\$3,776 50
Interest on Savings Account, December 10, 1941, to December 21, 1942	37 40
Interest on Liberty Bond 45554-D	1 44
From three Life Memberships	150 00
Total	\$3,965 34

## EXPENDITURES

(None)

Balance in Savings Account, December 21, 1942	\$3,965 34
One Liberty Bond 45554-D	50 00
Balance in Permanent Fund	\$4,015 34

## RESOURCES

Liberty Bond, 45554-D	\$ 50 00
Balance in Savings Account	3,965 34
Balance in Checking Account	2,424 93
Total	\$6,440 27

Respectfully submitted,

CLARENCE E. MICKEL, *Treasurer*.

## REPORT OF THE MANAGING EDITOR OF THE ANNALS

The *Annals* for 1942 will be a volume of 484 pages as against 868 for 1941. The large volume for 1941 made an overdraft on 1942 income in an attempt to clear the great amount of manuscript on hand. The small volume for 1942 has been kept exactly within the amount set aside for the *Annals* by SECRETARY-TREASURER MICKEL for 1942.

The *Annals* has been aided by a gift of \$500 00 from an anonymous friend who admires its good looks, and by a series of articles the printing costs of which have been paid for by the author or the author's institution. These are the University of Utah for R. V. Chamberlin and W. Ivie, \$100 00; Richard Dow, \$37 00; Thomas A. Hart (two articles), \$77 50; and the Gorgas Memorial Institute, for five Fairchild articles, \$214 50; a total of \$584 00. This amount is for printing and does not include cost of cuts also paid for by the authors. At little cost (postage, etc.) to the Society these articles added about 120 pages to the 1942 volume.

With the war and loss of foreign subscriptions, the latter have dropped from 240 to 196, an income loss of \$242 00. With some emphasis on descriptions of new species of Central and South American insects to make our *Annals* of use

to South American institutions we should in the next few years be able to add a substantial number of South American institutions to our list. Otherwise the *Annals* is of little interest to South American entomologists. At present we have only eight such subscribers. Brazil alone has 70 journals which publish biological articles. With the present efforts at good will towards the southern countries the Society could help in this manner and would help itself in building income, permanent from year to year, except for war. In periods of hard times the subscription list is the backbone of Society income as it varies little from such causes. Memberships come and go, but the usual institutional subscription is permanent until mails close against it on account of war.

The Society can be very grateful to the authors of recent articles for the high quality of the same. Articles that in years past would have been sent past the *Annals* to recognized zoological journals are now coming to the *Annals* in number up to the capacity of the *Annals* to use them. Every effort has been made in editing to give articles pleasing illustrations and an attractive format. The *Annals* is then rewarded with high grade material which in turn brings in more high grade material.

The Managing Editor has succeeded in having the Ohio State University give PROFESSOR DONALD J. BORROR one-third of his teaching schedule time for work on the *Annals*. PROFESSOR BORROR is a meticulous proof-reader and has helped in pinches before. The time of BORROR as Assistant Managing Editor amounts to an annual gift from the Ohio State University to the *Annals* of approximately \$900.00.

The financial summary follows:

RECEIPTS	
Non-member subscriptions.....	\$ 880.58
Back numbers and reprints.....	357.38
From authors for cuts and printing.....	522.02
Gift to the <i>Annals</i> .....	500.00
Undeposited checks from 1941.....	18.00
Bank balance December 20, 1941.....	46.17
Total.....	\$2,324.15
EXPENDITURES	
To engravers.....	\$ 446.59
Office help.....	240.00
Postage.....	63.60
Miscellaneous.....	28.33
Undeposited checks.....	5.37
Bank balance December 18, 1942.....	40.26
To Secretary-Treasurer.....	1,500.00
Total.....	\$2,324.15

Respectfully submitted,

CLARENCE H. KENNEDY, *Managing Editor*.

#### REPORT OF THE TREASURER OF THE THOMAS SAY FOUNDATION

RECEIPTS	
Balance on hand, December 23, 1941.....	\$327.29
From 1941 sales, not previously reported.....	9.70
1942 sales of Volume I—1 at \$3.00.....	3.00
1942 sales of Volume II—2 at \$4.50.....	9.00
1942 sales of Volume II—1 at \$5.00.....	5.00
1942 sales of Volume III—2 at \$3.60.....	7.20
1942 sales of Volume III—2 at \$4.00.....	8.00
Interest to June 30, 1942.....	4.98
Total.....	\$374.17

## EXPENDITURES

Postage.....	\$ 1.51
Total.....	\$ 1.51
Balance in Purdue State Bank, January 18, 1943. ....	\$372.66

The manuscript for Volume IV, "The Blowflies of North America," has been submitted by the author, DR. DAVID G. HALL, and your committee hopes to secure publication the coming year.

Respectfully submitted,

J. J. DAVIS, *Editor and Treasurer.*

## REPORT OF THE AUDITING COMMITTEE

We, the undersigned members of the Auditing Committee, beg to report that we have carefully examined the accounts of the Treasurer of the Society, the Managing Editor of the Annals and the Treasurer of the Thomas Say Foundation for the year 1942, and have found them to be correct and properly balanced.

Respectfully submitted,

JOSEF N. KNULL,  
B. ELWOOD MONTGOMERY,  
JOHN H. HUGHES, *Chairman.*

REPORT OF THE REPRESENTATIVE TO THE COMMITTEE ON  
BIOLOGY AND AGRICULTURE OF THE NATIONAL  
RESEARCH COUNCIL

The meeting of the Division of Biology and Agriculture of the National Research Council convened at the Academy of Natural Sciences, Washington, D. C., on Saturday, April 11, 1942. The agenda consisted of the following:

The minutes of the Annual Meeting of April 12, 1941.

Expansion of Activities of the Division in Latin America.

Reports of Committees.

## MATTERS OF ENTOMOLOGICAL INTEREST (proposed by entomological representatives.)

1. The need for a united national *all-out war program* for entomologists in the United States.

Attention was called to the careful preparations in England and the almost complete use made of the entomologist in the programs involving

- (1) Agricultural Entomology. Production of crops.
- (2) Stored food and clothing, protection and conservation.
- (3) Medical and Veterinary Entomology.

2. The need of a definite emergency program among the educational and research institutions of this country towards

- (1) Aid to the government in respect to food production and conservation.
- (2) Maintaining a high level in the instruction and training of entomologists for the war effort.
- (3) Maintaining necessary numbers of the best trained entomologists in all needed fields served by the entomologists as
  - (a) Medical and sanitary entomology.
  - (b) Crop production.
  - (c) Food conservation and protection.
  - (d) Animal protection.
  - (e) Protection of wool, leather, fabrics, wood, etc.
  - (f) Protection of rubber-producing plants.



3. Recommendations of the Entomologists<sup>1</sup> to the "General Committee of the National Research Council" for immediate action.

(In view of no committees or reports from entomologists.)

- (1) The deferment of entomologists engaged in teaching, research, or practical work necessary to the war effort.
  - (2) Provisions for the continuation of teaching and training men in entomology for the duration of the war and for the reconstruction period following the war.
  - (3) Provisions for protection against insects in relation to
    - (a) Human life in camps.
      - (1) Such disease-bearing insects as fleas, lice, mosquitoes, flies, etc.
      - (2) Tormenting insects, as flies, bedbugs, cockroaches, gnats, etc.
    - (b) Growing crops.
    - (c) Stored food products.
    - (d) Clothing fibers, wool, wood, etc.
4. The need for a Committee on Plant Protection within the National Research Committee. This matter was fully discussed and a committee authorized to consist of Entomologists and Plant Pathologists, as follows:

*Entomologists:*

J. L. HORSFALL, American Cyanamid Co., New York, N. Y.  
 T. H. FRISON, Illinois Natural History Survey, Urbana, Ill.  
 A. S. HOYT, Bureau of Entomology and Plant Quarantine, U.S.D.A., Washington, D. C.  
 DWIGHT ISELY, University of Arkansas, Fayetteville, Ark.  
 C. E. PALM, Cornell University, Ithaca, N. Y.  
 E. O. ESSIG, University of California, Berkeley, Calif.

*Plant Pathologists:*

E. C. STAKMAN, University of Minnesota, Minneapolis, Minn.  
 R. J. HASKELL, U. S. Department of Agriculture, Washington, D. C.  
 M. W. GARDNER, University of California, Berkeley, Calif.  
 J. E. MELHUS, Iowa State College, Ames, Iowa.  
 G. M. ARMSTRONG, Clemson College, Clemson, S. C.  
 J. G. LEACH, West Virginia University, Morgantown, W. Va.

This committee was authorized to hold meetings and conduct its work as deemed advisable. It was instructed to work with and to report to the General Committee.

However, since no chairman was appointed, the committee has been unable to function.

On November 19, 1942, in response to a report I made to Dr. GRIGGS, Chairman of the Division of Biology and Agriculture, a letter was received from the latter announcing a Committee on Crop Protection composed of a personnel quite different from that named on the Committee on Plant Protection already provided for. Whether this new committee replaces the former one or not is at present unknown to the writer.

Respectfully submitted,

E. O. ESSIG, *Representative.*

<sup>1</sup>By E. O. ESSIG, Representative of the Entomological Society of America, and C. E. PALM, Representative of the American Association of Economic Entomologists.

REPORT OF THE JOINT COMMITTEE ON COORDINATION OF  
ENTOMOLOGY WITH THE WAR EFFORT

The two entomological organizations at their meetings in San Francisco December, 1941, adopted a special joint resolution (*Annals Ent. Soc. Amer.*, Vol. XXXV, p. 133; *Jour. Econ. Ent.*, Vol. XXV, p. 132) as evidence of a patriotic determination of the members to direct the professional efforts of entomologists into lines of maximum usefulness to the government and people of the nation in a period of unprecedented crisis. The resolution expressed the consciousness of members of the entomological profession of an unquestioned need for constructive leadership and for unified effort, and to attain these essential ends, the resolution specified certain steps which it seemed desirable to take at the earliest practicable moment.

Acting on the recommendations made to him in this resolution, the Chief of the Bureau of Entomology and Plant Quarantine on January 31, 1942, communicated with various leaders in entomology relative to the holding of a special conference to institute and work toward the indicated objectives. The replies received apparently did not indicate that a fairly representative attendance might be expected, inasmuch as he (March 5) asked the president of the two entomological organizations to designate a committee to confer with him. Acting on this suggestion PRESIDENT WEISS of the American Association of Economic Entomologists and PRESIDENT ALEXANDER of the Entomological Society of America named MESSRS. F. L. CAMPBELL and C. H. RICHARDSON.

MESSRS. CAMPBELL and RICHARDSON conferred with the Chief of the Bureau of Entomology and Plant Quarantine and with others, and indicated one line of action as immediately important. They recommended the appointment of a Joint Committee of the American Association of Economic Entomologists and the Entomological Society of America to act in a liaison capacity between civilian entomologists and the military services. They suggested a plan of acquiring information on entomological personnel and other matters which would help to bring about further professional utilization of entomologists in the military services. The committee appointed by the two societies consists of MESSRS. ERNEST N. CORY, ROBERT MATHESON and F. C. BISHOPP, Chairman.

At the San Francisco meeting, the American Association of Economic Entomologists authorized the appointment of a committee to work with manufacturers of insecticides and with governmental agencies concerned with priorities of such materials, and to keep entomologists informed regarding changes in the availability of insecticidal materials. This committee was formed by the appointment of MESSRS. C. C. HAMILTON, R. C. ROARK and J. L. HORSFALL, Chairman, designated as the Committee on Insecticide Supplies. The committee is functioning, and is also co-operating with a similar committee concerned with fungicides. These two committees are unrelated to the Committee on Coordination of Entomology with the War Effort, and the appointment of these committees will indicate why the Committee later established does not deal with these subjects.

In the opinion of PRESIDENT WEISS and others, the tasks of these two special committees failed to include the entire emergency effort contemplated in the joint resolution. On April 20, 1942, he appointed a Committee on Coordination of Entomology with the War Effort, consisting of MESSRS. JOHN S. HOUSER, L. M. PEAIRS, P. D. SANDERS, FRANK N. WALLACE and E. F. PHILLIPS, chairman. On recommendation of the Committee, PRESIDENT WEISS invited the Chief of the Bureau of Entomology and Plant Quarantine to nominate a member of the administrative staff of the Bureau to take membership on the Committee, and AVERY S. HOYT was so nominated and appointed. The Committee also recommended that the Secretary of the Association, ERNEST N. CORY, be named on the Committee, and this was done. Subsequently the Entomological Society of America designated S. A. GRAHAM as a representative of that organization on the Committee. The present Committee then consists of the eight persons named, of whom five are members of both organizations.

The originally appointed Committee met in College Park, Maryland, May 8 to 10. It reported to the Executive Committee, and this report was published in the belated April issue of the *Journal of Economic Entomology*, advising that

coordinators be indicated for the control of the more important insect pests, to carry control recommendations to the grass roots as soon as possible.

After approval of the plan recommended by the Committee, and by arrangement of the entire Committee, MESSRS. CORY, SANDERS, HOYT and PHILLIPS met in Washington, June 10 to 12. Aided by heads of various divisions of the Bureau of Entomology and Plant Quarantine, a survey was made of the most important insect pests of those agricultural crops for which increased quotas had been established by the Secretary of Agriculture, and for each such insect pest or group of pests, a member of the Association was selected as a leader to head an attack on the problem of furnishing information on methods of control as quickly as possible to those on the firing line of production. To conduct these tasks, the Committee selected entomologists without regard to administrative affiliations, making the selections on the basis of qualifications and skill in conducting such undertakings. The Committee was well aware that it possesses no authority to make such assignments, but it was equally aware that entomologists are ready and willing to take on any extra task, if it gives promise of aiding the war effort.

There are still other problems for which an active emergency campaign would be helpful, and the Committee advised entomologists to set up their own plans for any of these. In at least one instance this is being done. In a few instances only did the Committee go beyond problems which pertain to increased crop quotas set by the Secretary of Agriculture. In cases in which the Committee knew that additional action was already under way it did not offer suggestions. The responses of entomologists have been in the affirmative, enthusiastic and heart-warming, and all the more satisfying at a time when members of the profession are called upon to carry an increased share of responsibility as citizens.

It would be futile to undertake an evaluation of an effort of this type. All that the Committee tried to do was to point out opportunities for service, leaving it to the leaders to select their own aids, to discover the most effective avenues through which to transmit the needed information and recommendations. Doubtless opportunities have been overlooked, and perhaps some of the efforts may prove ineffective, but the Committee did its best to indicate important problems and to allocate them to entomologists well qualified for the extra tasks. It is hoped delay and confusion in disseminating useful information has been avoided to a substantial degree.

It was planned that at the annual meeting periods would be set aside during which the men involved in the special problems considered by the Committee might have opportunity to get together for informal conference, and for the making of plans of attack for 1943. Time had been designated for the leaders of various problems to discuss the work under way. Inability to hold the annual meeting made these plans impossible to carry out, hence leaders of various projects will find it necessary to continue their work by correspondence. The methods of attack must differ, and in many cases the cooperation of the extension service or of some other organization would be helpful. Sometimes special publications, posters or some other material might be demanded, and sometimes personal contacts are more vital than printed directions. The Committee reached the limit of its powers, abilities and ambitions when it selected a strong leader and asked him to undertake the job.

The Committee has published a list of special projects and the names of the men who seemed abundantly qualified to undertake the tasks. All of us hope that as a result of these requests for cooperation, an even more united attack may be made on our insect enemies at a time when insect pests must be considered as allies of the totalitarian powers. We have faith that those who have accepted these responsibilities will use their utmost efforts to carry to the actual users full available information on known control measures.

In discussing cooperative efforts among entomologists, it would be a gross oversight not to suggest briefly the extent to which such cooperation already exists. In its first report, the Committee indicated the existence of regional branch organizations and subject matter sections, in all of which men of allied entomological interest get together. Under the auspices of the Association of Economic Entomologists, men engaged in work on codling moth and other fruit insects of various areas, pea aphid, tobacco insects and the like, meet annually to exchange results, to stimulate each other by suggestions and criticisms and to

set about the heavy task of making their efforts more useful. It is doubtful if among men of any other branch of scientific work there is better cooperation than already exists among entomologists. The National and branch Plant Boards are added instances of cooperation of this type, extended in these cases to include plant pathologists and men officially responsible in quarantine activities. All this cooperation, set up in days of peace, gave the Committee a feeling of assurance that one may expect hearty cooperation from entomologists when an opportunity is presented or can be discovered. In seeking to increase this cooperative endeavor, the Committee feels that it is best following out a primary intent of the joint resolution.

The Committee considers it important to make known to entomologists that the National Research Council has formed a Committee on Crop Protection, composed of plant pathologists and entomologists, under the chairmanship of PROF. E. C. STAKMAN, who is also chairman of the War Committee of the Phytopathological Society. This committee, consisting of J. G. LEACH, J. L. HORSFALL, J. G. HORSFALL, W. P. FLINT and E. F. PHILLIPS, met in Washington on October 15. This National Research Council committee presents a favorable means for developing even more cooperation between entomologists and plant pathologists. It seems appropriate also to state that the Phytopathological Society is well organized in the war effort.

The Committee recognizes that the curtailment of activities of the Insect Pest Survey issued by the Bureau of Entomology and Plant Quarantine has been a vital loss to services which entomology can render in the battle against insect enemies, and in the present emergency this loss is felt in exceptional degree. Since delay would make any appeal inconsequential, the Committee on October 17, 1942, addressed a letter to the Director of the Budget urging the re-establishment of the Survey in full. The Committee feels that this action will meet with universal approval of entomologists.

The Committee was specifically asked to consider a problem, important not only to entomology, but equally to other lines of work, the authorized reorganization of research in the Department of Agriculture. On December 13, 1941, the Secretary of Agriculture issued Memorandum No. 960 entitled "Organization of Department for War Effort." This memorandum begins as follows:

"In order to increase to the fullest possible extent the contribution of the Department of Agriculture toward winning the war, I am reorganizing the Department's administrative machinery.

"The seventeen line agencies that now report directly to the Secretary are being grouped for more effective action and coordination under the direction of eight group administrators.

"I am establishing an Agricultural Defense Board composed of eleven Department officials.

"Through this Board and the grouping of the line agencies, we hope to contribute our maximum effort to the primary responsibility of American agriculture during the emergency—the production of the food and fiber needed by this country and her allies.

"To this task, all others must be subordinated.

"I feel that the reorganization will enable the Offices of the Secretary, the Under Secretary, and the Assistant Secretary to concentrate upon the production program and other vital wartime programs. I feel also that the changes will enable the Department to centralize responsibility for the execution of these programs; to center research activities of the Department upon war needs; to produce abundantly without soil waste and destruction; to move toward a reduction in the number of Department agencies in the field which farmers must contact; and to enable the Department to meet all increased duties and responsibilities with greater efficiency and economy."

The grouping of the 17 line agencies referred to in the foregoing quotation as it was carried out with respect to the Bureau of Entomology and Plant Quarantine is covered in a later paragraph which we quote:

"During the first World War, the scientific research agencies of the Department made notable contributions to victory. We hope to see to it that these agencies are even more effective during this war. Therefore,

I am grouping together the Bureau of Animal Industry, Bureau of Dairy Industry, Bureau of Plant Industry, Bureau of Agricultural Chemistry and Engineering, the Bureau of Entomology and Plant Quarantine, the Bureau of Home Economics, the Office of Experiment Stations, and the Beltsville Research Center. These agencies will also retain their Bureau status, but their activities will be under the supervision and direction of an Administrator acting as my personal representative."

Secretary Memorandum No. 960 states with respect to the group administrators that:

"In the exercise of the authority vested in him by paragraph 1 of this memorandum, and in accordance with the applicable laws and regulations, the Administrator, or the Acting Administrator, shall, among other things, with respect to the agencies placed under his direction,

- a. direct and supervise their activities;
- b. direct and supervise the work of their officers and employees;
- c. delegate, in his discretion, his authority to their officers and employees;
- d. utilize their personnel, funds, property, and services; and
- e. consolidate or integrate their administrative, technical, staff, and other services."

Later, under date of February 24, 1942, Executive Order No. 9069 consolidated certain agencies within the Department of Agriculture, the grouping being along the lines indicated in Secretary's Memorandum No. 960. This was followed on February 25 by Secretary's Memorandum No. 986 entitled "Establishing Agencies of the Agricultural Research Administration." The Executive Order and Secretary's memoranda outline the authority of the Agricultural Research Administrator. Broad powers are granted to make such changes in organization as may be deemed necessary. Since the authority thus granted might permit reorganization of existing groups on a crop basis or on any other basis, desired by the Administrator, concern was felt for the future of entomology. The authority granted in the Executive Order remains "in force during the continuance of the present war and for six months after termination thereof," but there is no time limit or period of duration fixed in the memoranda issued by the Secretary of Agriculture to indicate a date of termination for the exercise of this authority.

A reason for concern arises from the fact that on previous occasions the integrity of the entomological work of the Federal government has been threatened. In the late nineties a plan was proposed to reorganize all the work of the Department on a crop basis, but this plan was averted. Many entomologists will recall that in 1933 a committee of administrators within the Department was reportedly prepared to recommend organization on a crop basis. Before this plan was put into effect, a joint committee of the two entomological organizations made presentations to the Secretary of Agriculture which averted such action for entomology, but at that time certain other lines of scientific work were organized on a crop basis. These two instances in which efforts have been made to organize work on some basis other than that of the branch of scientific work involved, naturally cause entomologists to be concerned whenever changes in administration of scientific work in the Department of Agriculture are proposed or authorized. It then seemed important that inquiries be made. This was even more important because of other administrative changes already made in the organization of the Department.

On June 10, three members of the Committee interviewed the Secretary of Agriculture on this subject. They were assured that he had no knowledge of a plan to organize on a crop basis. Members of the Committee have been informed that the Administrator has stated that he has no intent of disrupting the existing bureaus or other organizations composing the Agricultural Research Administration. The Committee thinks it appropriate to express its gratification of this assurance of the continued status of the Bureau of Entomology and Plant Quarantine.

In view of the sweeping changes which have been made in the agencies of the Department by other group Administrators, the Committee believes that so long as this authority remains unchanged, watchfulness on the part of entomologists is essential to avoid later interpretations of this memorandum. We should be

on the alert for indications along the line of gradual encroachments in the administration of the Bureau and drastic reorganization plans or for the superimposing of administrative direction, which might not promote the best interests of entomological work.

Concern among entomologists at administrative changes actually rests on the eminence of the entomological work of the Department, which to entomologists is a matter of pardonable pride. The Bureau is the entomological capital of the world. In no country other than the United States has it been more imperative that effective control measures be found for insect pests. Importation of crop plants, development of specialized agriculture, changes of hosts of native species of insects and other changes in agriculture, especially since the Civil War, have made possible concentrations of insect populations, which unless curbed, would have dedicated far too much of our crops to the feeding of insects. The destruction caused by insects constitutes truly an enormous burden on citizens of the country. At a time when maximum crops are so important, losses from insects become still more vital, and entomologists know that even with the best control measures, losses remain too high. It has thus been necessary that under the federal government there be maintained a great fighting force to protect our economy from insect enemies. It is no surprise that federal work in entomology has risen to the top.

The war against the insects requires coordinated effort, and cooperative work has been developed between federal and state organizations, for widespread education as to the damage done by insects, in methods for their control, for unity of action, and more recently for the application of methods of adult education and for programs of eradication, all of which have made results of research more effective. The need of manpower has led to the growth of departments of entomology in various educational institutions often larger than departments in the broader field of zoology. Throughout this development, the Bureau retains a place of pre-eminence in almost every field except the training of entomologists which is outside its competence.

Inevitably in such a growth there have been occasions when differences of opinion have arisen between federal and state men, and sometimes questions of legal authority. Full harmony in so quickly developing a field would be evidence only of laxity. There is no reason for glossing over such situations, because, despite all occasions when policies of the Bureau have been questioned, all entomologists realize that from its strength, its strategic position and its manpower, the Bureau must be accorded first place in all the world in the battle against insects. Entomologists grant to the Bureau this place, and desire to have that place retained.

Not only has the Bureau provided leadership within the country, but its influence is world-wide. Entomologists of the Dominion of Canada have cooperated freely and have carried their full share of the load, in research and in methods of application. With Mexico and other lands of Ibero-America, partly because of our national policy of being good neighbors, but primarily independent of all political consideration, the Bureau cooperates to the benefit of all countries concerned. Only the work of the federal government could thus make itself felt all over the world. In a time of global war, much international cooperation is hampered, but if unmolested, the Bureau will later be prepared to renew its happy relationships with entomologists of the world. Probably no other American group in applied science has done more for international harmony than has the Bureau as the national representative of applied entomology. If the entomological work of the government had been organized on any basis other than that of the branch of science concerned, or if it had been merely a small unit in a huge over-all scientific administration, this committee believes such international cooperation could not have been developed.

The Committee then advises that the effort undertaken by action of the President of the American Association of Economic Entomologists be considered as a preliminary step, that plans for future efforts be considered with great care, and that provision be made whereby cooperative efforts may be increased and so planned as to prepare the profession of entomology for its far heavier tasks of the near future. Tasks ahead are heavier than any so far faced, and unless entomology justifies its existence through enlightened initiation of services, it will utterly have failed in its great opportunity. In this entomology will not fail.

Scores of entomologists have discontinued their accustomed work to meet the obligations arising from the war, and many more will be called upon either to drop their usual work or to take on added duties. Probably most of us for months and years to come will find that the work which we prefer, and even the work for which we are best equipped, is not that which yields the best results in the war effort, and whatever changes in duties may be indicated will be accepted gladly. Not only must we accept new obligations when they are pointed out to us, but we must seek through combined strength to anticipate opportunities, to discover other ways to serve and to prepare ourselves and others for opportunities not yet made clear. The appointment of a committee as a sort of clearing house for such work should in no degree be considered a solution of the problem of adjusting entomology to the needs of the time. In searching for opportunities by which entomologists may be of service, we shall remember that entomology cannot be helpful until its usefulness is evident to persons other than entomologists. All these things we shall do in a determination that one day we shall regain the freedom to do those things in entomology which most appeal to us, freedom to plan our own lives and freedom to serve in ways which we consider best, which are only other ways of stating the freedoms for which all free men now fight. Nothing now is so important as the winning of the war, and to that high cause entomologists dedicate themselves.

Respectfully submitted,

ERNEST N. CORY,

JOHN S. HOUSER,

L. M. PEAIRS,

FRANK N. WALLACE,

S. A. GRAHAM,

AVERY S. HOYT,

P. D. SANDERS,

E. F. PHILLIPS, *Chairman*.

#### REPORT OF THE JOINT COMMITTEE ON MILITARY ENTOMOLOGY

PRESIDENT WEISS, of the American Association of Economic Entomologists, and PRESIDENT ALEXANDER, of the Entomological Society of America, appointed a committee consisting of DR. C. H. RICHARDSON and DR. F. L. CAMPBELL to collaborate with DR. P. N. ANNAND in initiating steps toward carrying out the intent of the following joint resolution adopted at the San Francisco meeting of these two entomological societies:

"WHEREAS, during this National Emergency the profession of Entomology is conscious of the need for leadership and organization of effort, and

"WHEREAS, the Bureau of Entomology and Plant Quarantine is in a unique position to furnish this leadership, and

"WHEREAS, time is a vital element in the development of a national program,

"Therefore, be it Resolved, that the Chief of the Bureau of Entomology and Plant Quarantine be requested to call together at the earliest practicable moment a group of entomologists representative of the various entomological organizations, institutions, and geographic areas of the United States for the purpose of ascertaining the best possible use of entomological personnel and facilities and for the development of a program for the most effective utilization of these resources, and that a copy of this resolution be sent to the Secretary of Agriculture and the Chief of the Bureau of Entomology and Plant Quarantine."

The committee met and made its report to the Presidents of the two Associations on April 6, 1942. The committee report made reference to its interpretation of the resolution and the field of its discussions as follows:

"The stated purpose of the resolution calls for a program for the most effective utilization during the war of both entomological personnel and facilities and therefore might be interpreted to include both military and civilian activities of entomologists. However, those who were present at the meeting of the Teaching Section in San Francisco where the resolution originated were of the opinion that its primary purpose was to facilitate the utilization of entomological personnel in the military services. Your committee therefore felt that it would be best to confine their discussions and recommendations to the military problem, as it seemed impossible to cover effectively a broader and unlimited field of civilian service."

It reviewed the possible relations of entomologists to the military, and nominated a committee to act for the two Associations—outlining its views as to the functions of this latter committee and suggesting that it be called "Committee on Military Entomology." It also proposed a questionnaire designed for use in assembling information on entomologists to aid the Army and Navy in securing properly trained personnel for entomological work and to provide data on entomologists for any specialized service that might arise in connection with the war.

Upon its appointment, the Committee on Military Entomology began to function at once by further developing contacts previously made with responsible officers in the Medical Departments of the Army and Navy where entomologists were urgently needed. Steps were also taken to prepare, print and distribute to the membership of the A. A. E. E. and E. S. A., through the secretaries of these societies, a questionnaire which was first presented to the military for comment. The distribution of the questionnaire was not restricted to the membership, however, since the committee's aim is to be of the greatest possible service to entomologists as a whole and especially to the military services.

Questionnaires, totaling 1,025, have been completed and returned. These have been classified according to expressed interest in entering the military service, and training and experience. They have been carded and records are maintained as far as practicable on those entomologists who have entered the military service.

The Committee on Military Entomology has maintained close contact with the personnel officers of the Army and Navy, and has supplied them, when requested to do so, with lists of entomologists available for service. The complete information as it appears on the questionnaire, together with information regarding these men as supplied in letters of recommendation, has furnished the basis for most appointments.

The Army has commissioned more than 100 men in the Sanitary Corps for entomological work. Some additional men will soon be commissioned and it is probable that this number will be added to materially during the year.

A few of the entomologists in the Army were reserve officers who were called to active duty and transferred to the Sanitary Corps, but most of them were commissioned as First Lieutenants. Four entomologists now rank as Lieutenant Colonels, 8 as Majors, and 14 as Captains.

The Hospital Corps Volunteer Service (H-V-(S)) of the Navy has commissioned a considerable number (figure cannot be divulged) of entomologists and some additional ones may be appointed during the year.

The entomologists entering the Navy were commissioned as Ensigns and Junior and Senior Lieutenants.

The Committee has been able to lend some assistance to the U. S. Public Health Service in finding entomological personnel for mosquito and other insect control work in extracantonment areas.

Consideration was given to the possibility of more fully utilizing the training and experience of entomologists volunteering or being inducted into the service, by having them detailed to entomological or other biological work. Accordingly arrangements were made to have entomologists included in the enrollment of medical technologists by the American Red Cross. Through this plan a number of entomologists have been assigned to the Medical Department where they will be available for detail to entomological work.

The opportunities for entomologists to perform useful service in branches of the Army other than the Medical Department have also been explored, and the attention of the Corps of Engineers and Quartermaster Corps has been directed to the ways in which entomologists might be advantageously used in those branches of the service. These Corps have made some use of entomologists of the Sanitary Corps and there is reason to believe that some men may be commissioned for full-time service in them.

The type of training best fitting men for entomological work in the armed forces has been considered and advice on curricula has been supplied to a number of universities. Naturally, under present conditions many difficulties are encountered in training entomologists but these are probably no greater than those confronted in other fields. The lack of training in medical entomology has been



forcefully brought out in connection with our efforts to assist the military in finding men ready to handle work in this field. Although men well trained in agricultural entomology have given satisfactory service with the armed forces, there is no doubt that their initial effectiveness would have been enhanced if all had received training in medical entomology as an essential part of their curriculum.

A rather extensive correspondence has resulted from inquiries as to opportunities and needs for entomologists in the military service. In this and in personal contacts of the committeemen an effort has been made to help entomologists evaluate their opportunities for service to our Nation, whether in the armed forces or in their present capacity as civilian entomologists.

Although the drain of the military demands for entomologists has been severely felt in some quarters, thus far it is thought that the needs have been reasonably well met and the number of entomologists has been sufficient to fill available positions.

The provision of special training courses for commissioned entomologists has been discussed with Army and Navy officials, but in general they have felt that provision of formal courses in medical entomology and supporting subjects is difficult to arrange and the needs of the service can be met by less formal training as now provided by the Army and Navy.

Return of troops infected with malaria, filaria, or other insect-borne diseases presents a menace to the civilian population. This should be provided for by starting now to develop post-war plans for the full utilization of trained sanitary entomologists and others (such as engineers, mappers, supervisors of labor, and developers of machinery for antimosquito work) mustered out of the service. This would absorb trained and experienced personnel, and help to protect the health of our people, thereby maintaining the productive capacity of the civilian population.

Efforts to impress military leaders of the importance of the maintenance in the military services, after the war, of an adequate number of entomologists should be considered a function of this committee. The protection of personnel, supplies, and installations from insect menace is a necessary continuing function of the armed forces that can be handled best by those now gaining experience under war conditions. Such men will be able to furnish the leadership quickly and effectively to implement entomological work in any subsequent emergency.

In order that the Committee may be of maximum service to military authorities and entomologists, it is essential that a record of the military allocation of every entomologist be available to the Committee. More than 500 such records are now available through the list that has been compiled in the office of SECRETARY CORY. Completion of this list is urgent and the Committee requests that those who have not sent in to SECRETARY CORY a record of their present military service do so at once. Those who have not sent in the War Work Questionnaire should send this immediately to DR. F. C. BISHOPP.

Respectfully submitted,

E. N. CORY,  
ROBERT MATHESON,  
F. C. BISHOPP, *Chairman*.

The following exhibits were to have been on display at the New York meeting:

1. The Common Insects of Kansas. ROGER C. SMITH, Kansas State College, Manhattan, Kansas.
2. Nine species of Hymenopterous Parasites Collected from *Eurukuttarus confederata* Grote, Including Two Unidentified Species. JOSEPH L. WILLIAMS, Lincoln University, Pennsylvania.
3. Life History of the Flat Grain Beetle, *Laemophloeus minutus* Olivier. NELLIE M. PAYNE, American Cyanamide Co., Stamford, Connecticut.
4. The Mosquitoes of the Great Swamp in Rhode Island. HERBERT KNUTSON, Rhode Island State College, Kingston, Rhode Island.

Respectfully submitted,

CLARENCE E. MICKEL, *Secretary*.

ANNALS  
OF  
The Entomological Society of America

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JUNE, 1943

No. 2

NOTES ON ODONATA OF SURINAM

IV.<sup>1</sup> NINE NEW OR LITTLE KNOWN ZYGOTEROUS NYMPHS  
FROM THE INLAND WATERS

D. C. GEIJSKES,  
Landbouw-Proefstation,  
Paramaribo, Surinam

The nymphs of the rich neotropical Odonate fauna are but very poorly known. In this contribution nine nymphs are described, of which seven were identified by rearing or by the study of the wing venation and the penis. These will be of importance for our knowledge of the nymphal characters in general and concerning the systematic position of some doubtfully arranged species.

The first five species are stream-dwellers, living in the running water of creeks and rivers, whereas the last four species are inhabitants of standing water and were collected in flat savanna pools or in small rivulets between these pools.

The mentioned species are all new records for this country.

***Oxystigma petiolatum* Selys**

Nymph (hitherto unknown), Plate I.

A short, stout-bodied, black-marked nymph, with swollen triangular gills. Head large, broader than long, the eyes less prominent, hind angles swollen, spinulose on the outer edge, occipital border highly excavated. Black markings as shown in fig. A, Plate I. Antennae relatively short, first segment with a darker ring, second segment somewhat darkened below, otherwise pale; relative length of the segments 16 : 23 : 22 : 20 : 12 : 8 : 8. Segments 1-2 covered with long, flattened scales, segments 3-6 with an apical fringe of hairs.

Mentum broad and somewhat quadrangular, reaching backward to just behind the first coxae, the sides in the basal half diverging, in

<sup>1</sup>Part I. *Rimanella arcana* Needham and its nymph (Odon. Zyg.). *Revista d. Entomologia*, 11 (1-2): 173-179; 8 figs. 1940.

Part II. Six mostly new Zygopterous nymphs from the coastland waters. *Ann. Ent. Soc. Amer.*, 34: 719-734; 6 figs. 1941.

Part III. The genus *Coryphaeschna*, with descriptions of a new species and of the nymph of *C. virens*. *Ent. News*, 54: 61-72. 1943.

the apical half more parallel, the margin in the middle for a larger part armed with teeth alternating with simple hairs. No mental setae present; median lobe rounded and irregularly denticulated, in the middle with a small cleft. Lateral lobes without lateral setae; movable hook large, end hook small and blunt, pointed downward, terminal border with two large dents; inner margin of lobe denticulated.

Maxilla of right side: end tooth with three small basal teeth, followed below by six larger setae and three smaller ones and with five lateral setae; inner side with three equally sized large teeth, followed below by six larger setae and three laterals. Left maxilla the same, but with three lateral setae (not five) in the outer row and with four laterals (not three) in the inner row.

Mandibles stout, two branched, external branch larger with five unequally sized teeth (4 and 5 fused together); right mandible with a basal tooth below the first large dent; internal branch of left mandible larger than that of right mandible, its apex truncated and with seven teeth or crenations, dorsal-most largest. On the right mandible the apex of the internal branch is pointed and has only two teeth. The basal outer corner of both mandibles with a truncated tridentate and hairy part.

Prothorax broad, hind margin convexly rounded, middle lobes and hind lobe with black areas, middorsal line in the apical half pale. Synthorax broad, as broad as head, intensively marked with black stripes in the front along the middorsal carina and on the sides along the lateral suture.

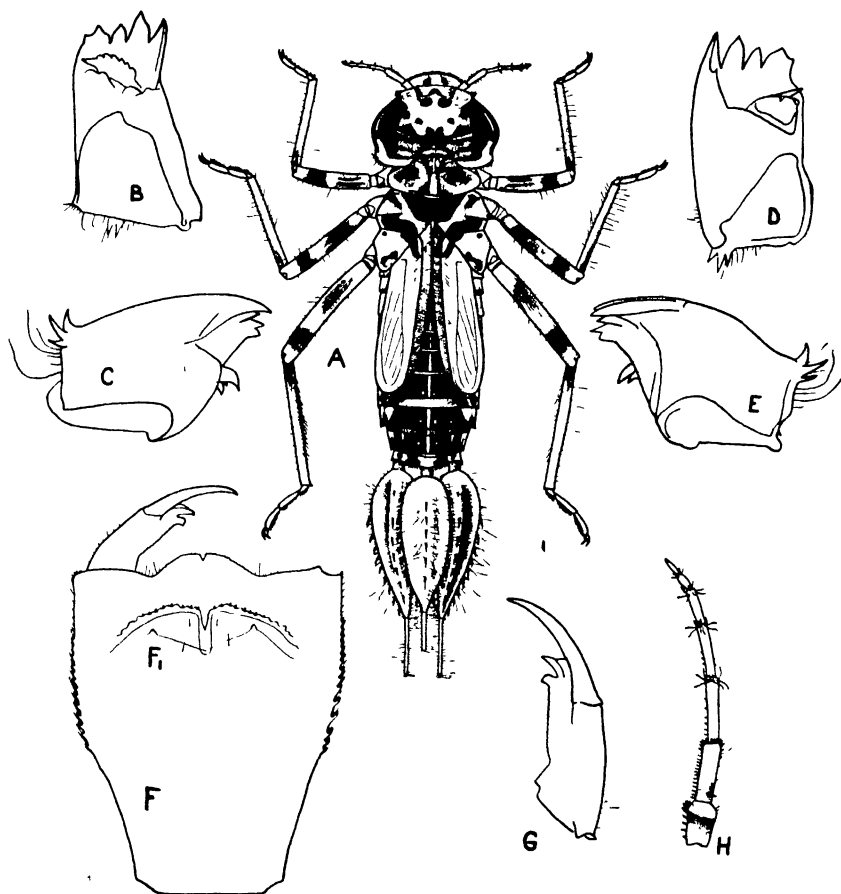
Wing pads reaching to mid-length of segment 7. Legs relatively long, femora not flattened, with a darker apical ring and a darker area more basally. Apical end of the first tibia and the three tarsal segments armed with plumose setae only, those of the middle and hind tibiae with plumose and simple setae and with three short, strong spines (spurs); middle and hind tarsi with simple and plumose setae on the first segment, on the second and third segment with plumose setae only. An empodium-like structure present between the claws.

Abdomen relatively broad, the last two segments much smaller, dorsal side in cross-section convex, ventral side flat. Dorsum for the most part dark with a middorsal pale line over all the segments, on segments 7-9 the dark area black on the sides and followed more laterally by a lighter part. On segment 10 the darker areas are reduced to four spots.

Gonapophyses of male absent and with no indication of elevated points.

Gills enormous, swollen, triangular in cross-section, petiolated at base and with a slender tail-like tip end. Swollen portion ovoid, flattened and somewhat impressed on the opposed surfaces, so that the dorsal and lateral margins are more or less ribbed. These ribs are armed with a row of strong curved spines; other parts and slender tips hairy.

Total length, including gills, 14.75 mm.; lateral gills 5.2 mm.; dorsal gill 4.4 mm.; abdomen 5.0 mm.; largest width of head 3 mm. One ult male examined.



*Oxystigma petiolatum* Selys. A, dorsal view of full-grown male nymph; B, left mandible, inner side; C, left mandible, lateral view; D, right mandible, inner side; E, right mandible, lateral view; F, mentum, inner side; F<sub>1</sub>, median cleft, enlarged; G, right lateral lobe of mentum; H, antenna.

This remarkable nymph was collected in the Makami-creek near Kabelstation, Sept. 22, 1938, where it was found between leaves and twigs in the clear running water. The identification was secured by a careful study of the wing venation. Imagines of this species were commonly found in the nearby woods.

In the system of Kennedy (1920), *Oxystigma* belongs to the Megapodagrioninae. This position seems to be correct according to the structure of the nymph, for the nymph has many features in common with some other genera belonging to this subfamily, such as the less cleft median labium border, the absence of mental and lateral setae, the terminal border of the labial lobe with two teeth, the two-branched (biramous) mandibles, and the shortened and swollen gills. The known nymphs of this subfamily are *Thaumaloneura* (Calvert, 1915), *Argiolestes* (Tillyard, 1917), and *Rhinagrion* (Needham, 1911; Needham and Gyger, 1939). The nearest relatives of *Oxystigma* in the Amphipteryginae, *Hypolestes* (Needham, 1911) and *Diphlebia* (Tillyard, 1909), do not have biramous mandibles (*Hypolestes*).

The nymph of *Oxystigma* differs from that of *Rimanella* (Geijskes, 1940) by the swollen gills, the lack of external gill tufts, and the divided labial lobe. It differs from the Epallaginae (*Pseudophaea*; Ris, 1912, and Needham and Gyger, 1939) and Polythorinae (*Cora*; Calvert, 1911) by the absence of the lateral abdominal gills, and from the Platystictinae (*Drepanosticta*; Lieftinck, 1934) by the toothed labial lobe, whereas the Agrioninae (Calopteryginae) and Libellaginae are differentiated by the hypertrophied first antennal segment and the deeply cleft mentum.

### ***Hetaerina dominula* Hagen**

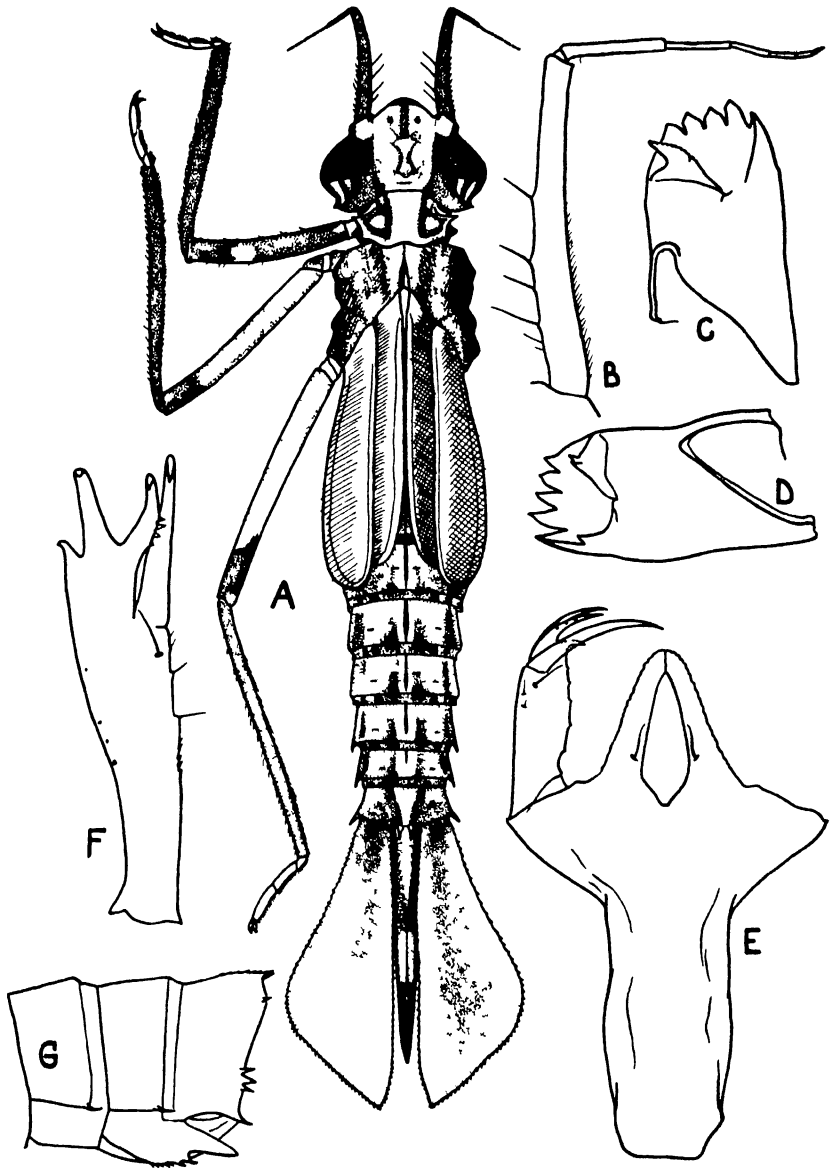
Nymph (hitherto unknown), Plate II.

A long stalky dull brown nymph with the triquetral lateral gills widened and with lateral spines on the last three abdominal segments.

Head moderately broadened and flattened, the eyes prominent and set forward, hind lobes toothed, occipital border widely excavated. Antennae with the first segment hypertrophied, longer than the remaining part, stalky, dark brown, inner side with a few (5-6) setae, outside hairy; relative length of the segments 125 : 40 : 24 : 15 : 7 : 7 : 8.

Mentum long, more or less spoon-shaped, reaching backward to between the second coxae, suddenly dilated in its apical half; median border very prominent and divided into two lobes by a median cleft, extending below to the level of the bases of the lateral lobes, the distal end of the cleft closed by the apposition of the two divisions of the median lobe; beside the cleft on either side is a single seta. Lateral lobe with a straight outer margin and with a long curved movable hook, just before the base of which on the superior margin are three small setae; terminal border with two large equally sized arcuated and somewhat diverging dents, the dorsal one with four denticulations along the upper margin; end hook smaller, inner margin of lobe slightly convex and serrulated.

End tooth of maxilla with three small basal teeth, followed by



*Helaerina dominula* Hagen A, dorsal view of full-grown female nymph; B, right antenna; C, left mandible, inner side, D, right mandible, inner side, E, mentum, inner side; F, right lateral lobe of mentum, G, end of abdomen of female, left lateral view.

seven larger setae and nine to twelve smaller lateral setae; upper inner margin with three large equally sized teeth, of which the last one is more curved, followed below by seven longer setae and six or seven smaller laterals.

Mandibles two-branched, the outer branch with five teeth of nearly equal size; right mandible with a basal tooth on the largest ventral dent; inner branch of right mandible with two teeth, that of left mandible with a truncated and denticulated plate.

Dorsum of prothorax with a lateral pointed prominence in the front part and with a less pointed or rounded prominence in the apical part. Synthorax as broad as head, wing pads reaching backward to the end of segment 5. Legs long and slender; femora lighter in the basal three-fourths, followed by a darker ring just before the knee, except in the first femur, which is darker from its base to the apical pale ring proximad of the darker end part; tibiae dark brown, tarsi paler; end of tibiae and tarsal segments beset with plumose setae.

Abdomen relatively broad, slowly tapering to the end; segments 8 and 9 with a sharp flat lateral spine; segment 10 with three spines on the lateral carina, and with two larger middorsal setae along the apical border and one smaller pair more laterally. Dorsum dull brown, a paler middorsal stripe over the last six segments, interrupted by a black line in the median to the basal half of segment 9; sides darker with some black spots.

Gonapophyses of male short, pointed, reaching to the end of segment 9, beset with a row of short setae; gonapophyses of female reaching to the end of segment 10, inner pair strongly curved upward, outer pair denticulated on the ventral margin, end tooth large.

Gills large, the two laterals triquetral and considerably widened in the apical half (length : width = 3 : 1), the apices rather pointed, the margins serrulated; the median gill flat and shorter than the laterals, dark brown with a paler part at two-thirds the length. In some darker individuals the lateral gills are banded with dark at the base and over the apical half.

Total length, including first antennal segment and gills, 22.0–22.5 mm.; first antennal segment 2.5 mm.; abdomen 8.0 mm.; lateral gills, 5.0–6.0 mm., median gill 4.5–5.0 mm.; largest width of head 3.0 mm. One male and one female ult nymph examined.

The nymphs of this common species were found in some creeks in the interior (Coropina-creek, Makami-creek near Kabelstation and Waremapan-creek in the Tumuc Humac Mountains) as well as in the falls of the Surinam river near Kabelstation. They rest between debris of leaves and twigs and between the large leaves of the Mourera-plants (Podostemonaceae) in the falls of the river. The species was identified from an emerging male from the Coropina creek (4. IV. 1942).

Of the numerous species of *Hetaerina*, only the nymphs of *H. americana* Fabr. (Needham, 1903) and of *H. titia* Drury (Byers, 1930) seem to be described at length. The nymph of *H. americana* differs from that of *H. dominula* by the less widened lateral gills, the lateral abdominal spines on segments 7–9 (instead of 8–9) and in the length of the two teeth on the terminal border of the lateral mental lobe, of which

the one next the end hook is twice the size of the other above it (in *dominula* the teeth are equal in size).

The nymph of *H. titia* is very similar to that of *H. dominula*, and according to the original description, there is no difference except its smaller size and some variation in the darker bands on the gills.

#### ***Hetaerina moribunda* Hagen (supposition)**

Among the *Hetaerina* nymphs in my collection there are three specimens which, although very similar to the described nymph of *H. dominula*, show the following points of difference: abdominal segments 7-9 with a lateral spine on the carina (on 8-9 in *dominula*), the general appearance smaller and paler, the legs pale, except a small black point near the apical end of the femora, and only the basal part of the first femur darker; lateral gills less dilated in the middle (length : width = 4 : 1), otherwise the same as in *dominula*; the first antennal segment longer, relative length of the segments 130 : 38 : 23 : 14 : 7 : 7 : 7.

Mouth parts and other details as in *dominula*.

Total length, including first antennal segment and lateral gills, 20.0-21.5 mm.; first antennal segment 2.3-2.5 mm.; abdomen 7.7-8.5 mm.; lateral gills 6.3-6.7 mm.; median gill 5.0-5.2 mm. Surinam, Kabelstation Makami-creek (22. IX. 1938), one male and two female ult nymphs examined.

The only other species of *Hetaerina*, besides *H. dominula*, found as adults along this and many other creeks in the lowland bush, is *H. moribunda* Hagen. The determination of this nymph is based on this observation.

#### ***Hetaerina* sp.**

From a springlet at the top of the Brownsberg (400 m.), two not full-grown nymphs were collected (16. IX. 1938) which are readily separable from the two foregoing species by a small elevation or knob at the apical end of the middorsum of abdominal segments 3-10 and by two setae on the median lobe of the mentum along the cleft. Some other peculiarities are as follows: eyes black on the outer half, this black prolonged forward over the sides of head to along the outer side of the first antennal segment and downward over the sides of the hind lobes of head. In the middle of head, four longitudinal, more or less zigzag, lines. Sides of synthorax and abdominal segments 1-5 with two lateral darker stripes, each side of segments 5-8 marked only with two black dots on the apical margin of the segment. Legs pale, femora with two darker rings, one in the middle and one more apically.

Hind lobes of head very prominent, with an obtuse tooth. Prothoracic dorsum quadrangular, in the middle of the side margins a toothed prominence, hind angle acute. A lateral spine on abdominal segments 8 and 9, lateral gills triquetral and moderately dilated in the middle (length : width = 15 : 4), three darker crossbands present, tip acute, margins serrulated.

Mentum reaching backward to between the second coxae, of the ordinary *Hetaerina* shape as in the preceding species; two setae along



the cleft in the median lobe, a smaller upper one and a larger one below; other mouthparts as in *dominula* and *moribunda*.

Total length, including first antennal segment and gills, 11 mm.; first antennal segment 1.48 mm.; abdomen 4.2 mm.; lateral gills 3.0 mm., median gill 2.6 mm.; largest width of head 1.65 mm. One female nymph not full-grown (3? ult) examined.

Total length, including first antennal segment and gills, 16 mm.; first antennal segment 2.18 mm.; abdomen 6.0 mm.; lateral gills 4.3 mm. (median gill broken); largest width of head 2.31 mm. One female nymph (not full-grown; 2? ult) examined.

Concerning the question to what species this nymph belongs, we are fully in doubt. Other species of *Hetaerina* found in Surinam and Demerara are *mortua* Hagen and *laesa* Hagen, but these were not observed on the collecting place. There is also a chance, although a very little one, that the species is a representative of another genus, viz., *Lais*, *Neocharis* or *Iridictyon*, the only other genera of *Agrioninae* known at present from Surinam and Demerara. As this question is only to be solved by future research work, it seems the best now to retain the species provisionally under *Hetaerina*.

### ***Argia insipida* Hagen**

Nymph (hitherto unknown), Plate III.

A stout-bodied nymph with large head and thorax, somewhat flattened femora and short oval gills; the body, legs and gills dark brown, spotted with lighter dots.

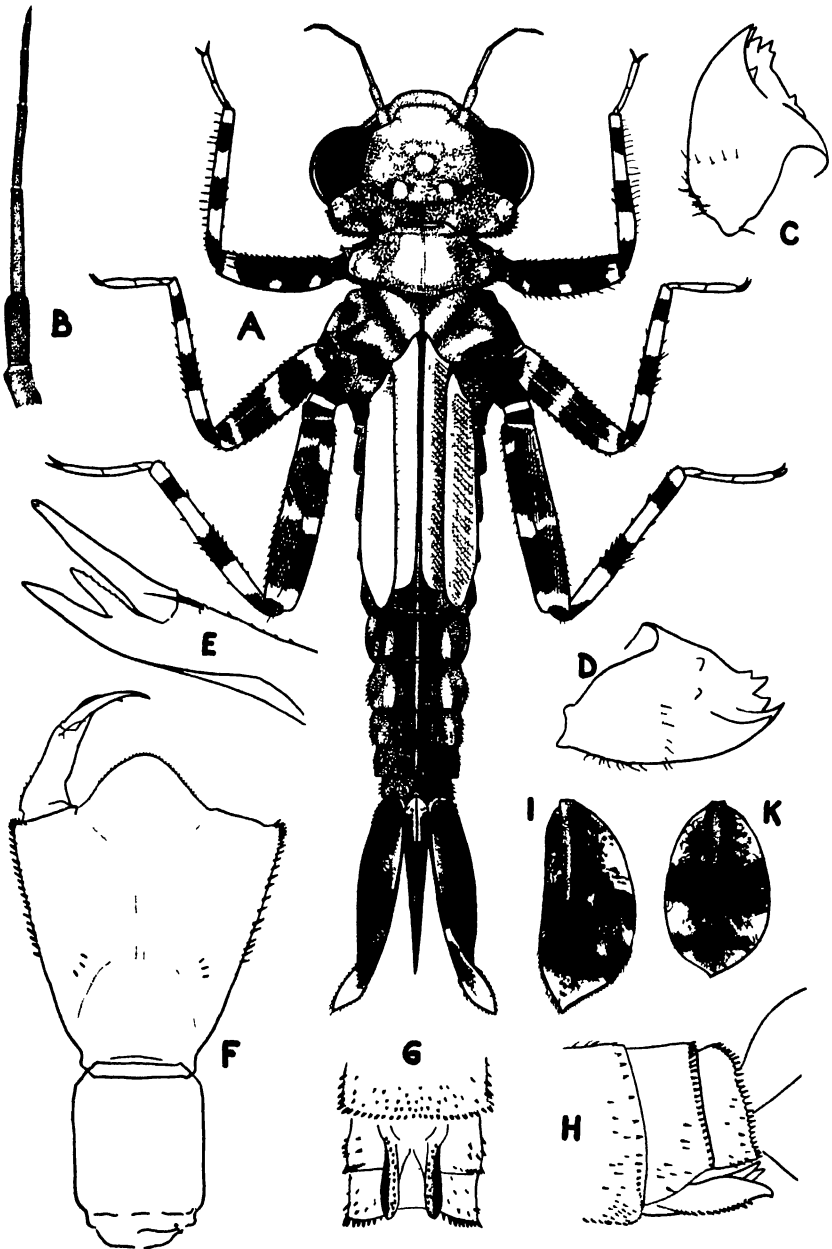
Head large, flat, broader than long (5 : 3), hind angles swollen and rounded, spinulose. Antennae thin and simple, 7-segmented, relative length of the segments 13 : 22 : 38 : 28 : 18 : 8 : 6.

Mentum broadly triangular, reaching backward to behind the first coxae, the sides diverging, armed with a row of small spines over the apical two thirds; no mental setae present, but in the basal part each side with three small spines; median lobe very prominent and rounded, finely denticulated. Lateral lobes with one slender seta; movable hook large and somewhat curved, end hook long, separated by a deep cleft from the terminal border, which consists of a long tooth, denticulated superiorly.

Maxilla of right side: end tooth with two basal teeth, followed below by five strong setae and several rows of finer setae, in total twenty; inner side with three large teeth of equal size, followed below by eight larger setae and six slender setae more laterally. Maxilla of left side: end tooth with two basal teeth, followed by twenty-four setae, inner margin with three large teeth of equal size, and with two rows each of nine finer setae.

Mandibles with five unequally sized teeth, both left and right mandible with two teeth on the inner surface, outer side with a transverse row of small setae.

Prothorax broader than long, flat, hind margin convex. Synthorax large, nearly as broad as head, the wing pads reaching in the female to the end of segment 5, in the male to the end of segment 4. Legs



*Argia insipida* Hagen. A, dorsal view of full-grown female nymph; B, right antenna; C, right mandible; D, left mandible; E, right lateral lobe of mentum; F, mentum, inner side; G, end of abdomen of male, ventral view; H, end of abdomen of female, left lateral view; I, left lateral gill; K, median gill.

large, the femora flattened, for the most part dark brown to black, with three white rings, one basal, one in the middle and one at the apical end; tibiae white, with three black rings; tarsi pale; apical end of tibiae with simple, divided (trident) and plumose setae, tarsi with plumose setae only.

Abdomen relatively broad, tapering to the end, dark brown with some lighter spots laterally and with a fine pale middorsal stripe over the segments; segments 7-10 densely spinulose. Male gonapophyses rounded, with a blunt apex, beset with a row of small short spines on the under side, reaching backward to the posterior margin of segment 10; female gonapophyses with the outer pair somewhat longer than the inner pair, reaching to beyond segment 10, the ventral margin with a row of short spines, apex curved downward.

Gills short and thick, oval-round with a small end point, the laterals longer than the middorsal gill, which is nearly round, largely darkened along the midrib and with two diffuse black crossbands; no spines, but along the margins in the laterals there is apically a row of short fine hairs; veins not visible.

Total length, including gills, 14-16 mm.; gills 3-4 mm.; abdomen 6-8 mm.; width of head 3.8 mm. One male and two female ult nymphs examined.

This conspicuously colored nymph was collected in the Surinam River near Kabelstation in the falls between Mourera-plants and fallen leaves (Sept. 21, 1938, one male and two females ult stage, one male in 3 or 4 ult stage) and in a falls of the Waremapan-creek in the Upper Litani River (July 30, 1939, one male in 3 or 4 ult stage). The nymph is a typical stream-dweller, resembling Ephemeropterid or Plecopterid nymphs by the flattened legs and by the strong broad head and thorax.

The species was not determined by breeding, but was determined by the penis of the adult male specimen, which was already developed, and by the wing venation. Mrs. Leonora K. Gloyd, who is revising the genus *Argia* and who has determined Surinam imagines, kindly informed me that *A. insipida* Hagen is the same species as *A. ierea* Geijskes described from Trinidad (Geijskes, 1932). The last name should therefore be regarded as a synonym.

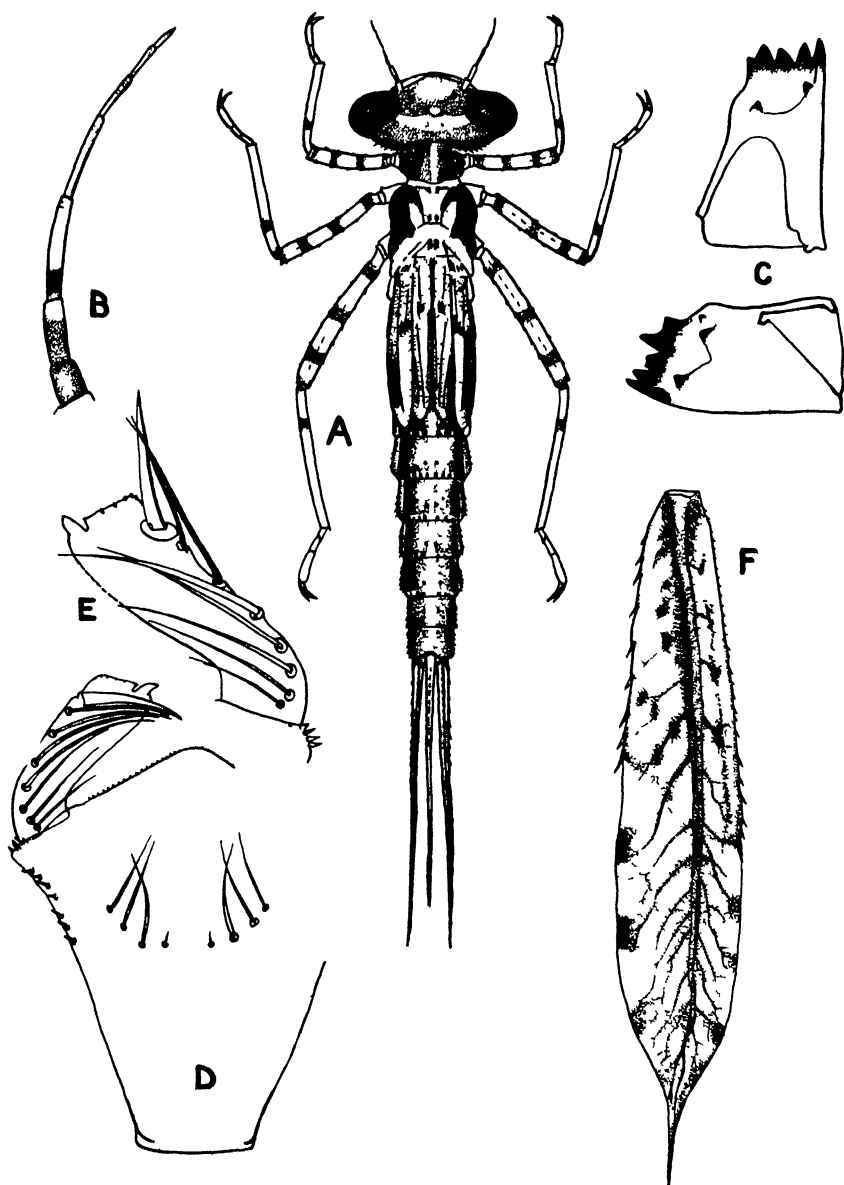
### ***Argiallagma minutum* Selys**

Nymph, reared, Plate IV.

A small slender nymph with black marked body, the abdomen partly spinulose and with long acute gills.

Head more than twice as broad as long, the eyes very prominent, hind angles slightly rounded and scarcely spinulose, dark brown, with a lighter band across the vertex between the eyes, occipital border black, slightly excavated. Antennae with segment 1 dark, 2 dark with the apical third pale, 3 pale with basal third brown, 4-7 pale; relative length of the segments 10 : 12 : 27 : 21 : 15 : 12 : 7.

Mentum broadly triangular, reaching backward to just behind the first coxae, the sides diverging, along the margin in the distal half with seven short setae; mental setae three, with a smaller one to the



*Argyallagma minutum* Selys. A, dorsal view of full-grown male nymph; B, right antenna; C, right and left mandibles, inner side; D, mentum, inner side; E, right lateral lobe of mentum; F, right lateral gill.

middle; median lobe prominent, the sides straight, the border finely denticulated. Lateral lobes with seven setae, movable hook well developed, end hook small, curved, separated by a notch from the terminal border, which is straight and not toothed but denticulated with five or six small spines.

Maxillae of right and left sides similar; two smaller teeth at base of the end tooth, followed by a row of eight setae and more laterally by a row of three setae; upper margin with three large teeth and eight setae below with one lateral seta.

Mandibles with five unequally sized teeth; right mandible with two teeth, left mandible with three teeth on the inner surface.

Prothorax shield-like, dark brown above with a paler middorsal stripe, sides black. Synthorax relatively small, the sides black, otherwise paler to brown; wing pads reaching to the end of abdominal segment 4. Legs pale, the femora with three darker bands and darkened at the knees; tibiae with one darker ring in the basal third. Apical end of tibiae with plumose and trident setae only.

Abdomen dark brown with lighter spots more above and with a pale middorsal stripe over the segments, tapering to the end, segments 5-10 with the lateral carina spinulose, segments 7-10 with short spines over the sides.

Male gonapophyses sharp pointed with two to four short setae, reaching to the basal third of segment 10.

Gills long lanceolate, tips very acute, nodus well marked at about midway the gill length, brownish, dotted with darker spots and in the apical half with three oblique darker bands, marked especially as three darker spots along the margins.

Length of lateral gills 4.8 mm., largest width 0.8 mm.; dorsal gill 4.2 mm. and 1.0 mm.; lateral gills with 9-10 setae at the dorsal margin and with a row of 22-25 short setae on the lateral carina and along the ventral margin. Dorsal gill with 5, 20 and 17 setae respectively on these places. Veins dull brown, scarcely branched.

Total length, including gills, 14.3 mm.; gills 4.6-4.1 mm.; abdomen 6.3 mm.; width of head 2.0 mm. One adult male nymph examined.

The specimen was collected in the 2 ult stage in a flat pool on the savanna near Zandery II along the railroad (6. II. 1942) where several imagines of this species were captured at the same time. The nymph moulted to the 1 ult stage on Feb. 20 and emerged on March 9.

The nymph of *Argiallagma minutum* Selys has been described in supposition after one female from Puerto Rico by Garcia-Diaz (1938). The Surinam example corresponds very well with the Puerto Rican specimen, so that there is no doubt concerning the determination of the species. The only differences are: four mental setae (P. R.) instead of three mental setae and a smaller one against the middle (S.); tibiae with no definite rings (P. R.), tibiae with definite rings (S.). In general the length of the Surinam specimen is greater.

The genus *Argiallagma* is characterized by its wing venation, and especially by the long spines on the tibiae in the imago. For this reason the genus is generally placed near *Argia* and its relatives (*Onychargia*, *Palaiargia*, *Diargia* and *Hyponeura*) which also have long spines on the

tibiae in contrast with the other *Coenagrionidae*. However if we consider the structure of the nymph of *Argiallagma*, it is evident that it has very little in common with that of *Argia* as far as known (nymphs of the other mentioned genera are not known), but shows close relation with *Aeolagrion* and to a less degree with *Telebasis*. Its systematic position near *Argia* on account of the long leg spines in the imago is also not justified by the nymphal structure and must be regarded as a case of convergence.

***Telebasis sanguinalis* Calvert (1909)**

Nymph (hitherto unknown), reared, Plate V.

A moderately slender nymph with a long abdomen and relatively short gills. Living colors green or dull dark brown with no definite darker markings.

Head twice as broad as long and wider than the succeeding parts of the body. Eyes prominent, hind angles rounded and spinulose; occipital border slightly excavated. Antennae about as long as head, 7-segmented, the two basal segments darker, otherwise pale; relative length of the segments 10 : 16 : 25 : 18 : 13.5 : 9 : 6.5. Mentum broadly triangular, reaching backward to between the first and middle coxae, the sides diverging, distally with five short setae along the margin. Only one mental seta and three smaller spines below each side. Median lobe prominent, the border finely denticulated. Lateral lobes with six setae, movable hook long, end hook well developed, separated from the finely denticulated terminal border by a deep cleft.

Maxillae with two smaller teeth at base of end tooth, followed by a row of eight setae and more laterally by a row of four setae. Upper inner margin with three large teeth and six to seven setae below with one lateral seta. Left and right maxilla the same.

Mandibles with five unequally sized teeth, right mandible with a denticle at base of largest lower dent and a knob along the upper inner margin; left mandible as in right mandible, but with two supplementary teeth or knobs on inner surface.

Prothorax shield-like, hind margin somewhat convex. Synthorax small, wing pads reaching to the beginning of abdominal segment 4. Legs pale, femora with one darker ring at the apical end, covered with some simple spines in the middle of inner side and with divided (trident) and plumose setae at end; tarsi with plumose and simple setae only.

Abdomen long and slender, slowly tapering to the end; segments 6-10 with a row of short spines on the hind margin and with some scattered setae on the sides on segments 7-10.

Gonapophyses of female extending to slightly beyond apex of segment 10, outer pair with five short spines and a few setae on ventral margin, apex long, conical. Gonapophyses of male short, reaching to the basal third of segment 10, sharp pointed with three or four short spines on the ventral side.

Gills lanceolate, about as long as the last five abdominal segments,

widest in the apical third, apex very acute; lateral ones with 22–25 ventral and with 25–26 lateral and 7 dorsal spines in the basal half. Middorsal gill with 16 ventral, 16 lateral, and 4 dorsal spines. Length of lateral gills 4.4 mm.; largest width 1.07 mm., median gill 4.50 mm., largest width 1.23 mm. Nodus not well marked at two-thirds the total length. Membrane with many branched and darkly pigmented veins, three darker spots on the ventral margin in the distal half and two such spots on the dorsal margin in the basal half.

Total length, including gills, 12.5–15.5 mm.; gills 4.5 mm.; abdomen 5–7 mm.; width of head 2.75–3.0 mm. Three males and one female examined.

Along the railroad near Zandery II (km. 62), several nymphs were found between the stems of an *Heleocharis* in a flat savanna pool, where young imagines of this species were commonly observed at the same time (6. II. 1942). Three males and two females were reared from this material a few days later.

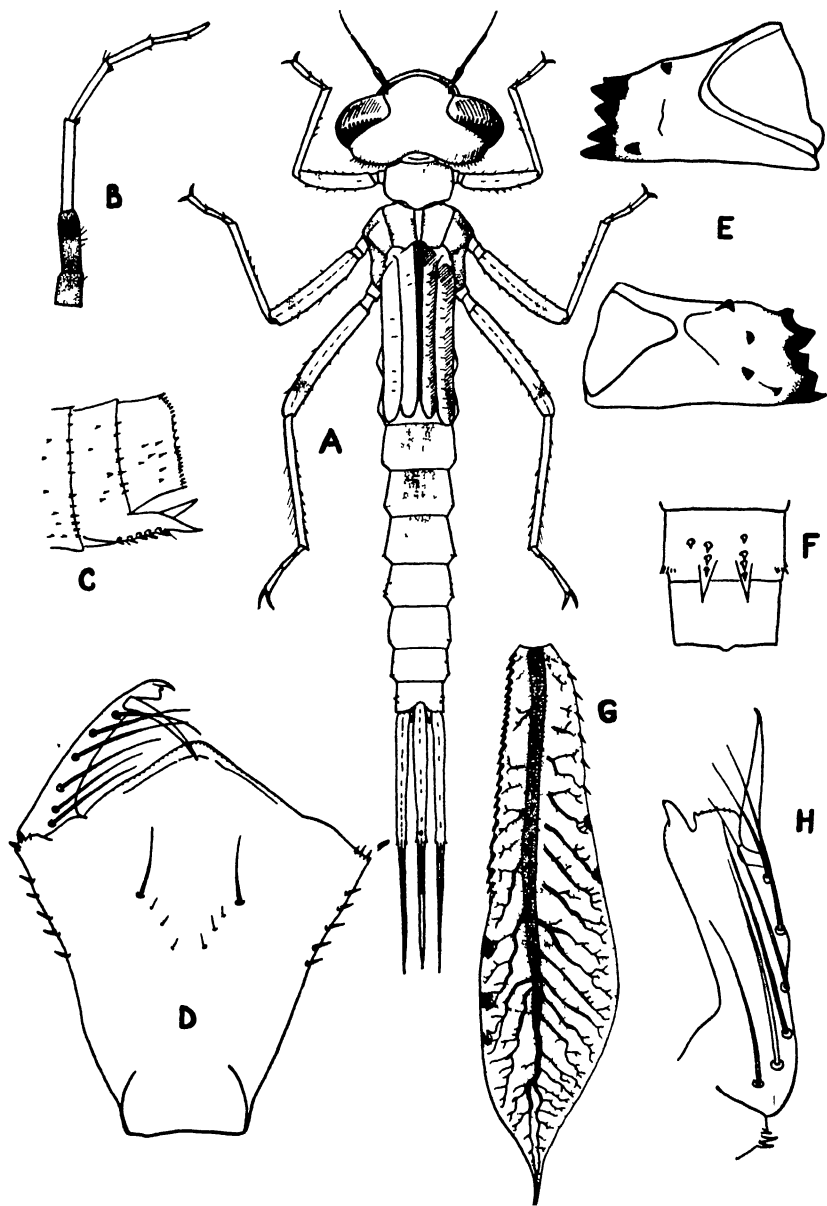
Nymphs of the genus *Telebasis* were described first by Needham (1904) from bred specimens of *T. salva* Hagen collected at Shovel Mountain, Texas. The nymph of a second species, *T. dominicanum* Selys, was described in supposition by Klots (1932) in the opinion that it was the same as that described by Needham (1904, p. 718) as *Leptobasis* sp. Garcia-Diaz (1938) thinks, however, that this nymph is really *Enallagma coecum* Hagen. This same author (*l. c.*) gives a description of the nymph of *Telebasis vulnerata* Hagen from the cast skin of a single reared female specimen from Puerto Rico.

Only two species of *Telebasis* are known without doubt in the nymphal stage, *T. salva* Hagen and *T. vulnerata* Hagen. The third species, *T. sanguinalis* Calvert (described above) differs from the other two as follows:

<i>T. salva</i>	<i>T. vulnerata</i>	<i>T. sanguinalis</i>
mental setae 3 <sup>2</sup>	mental setae 3	mental setae 1
lat. setae 4–5 <sup>2</sup>	lat. setae 6 (7)	lat. setae 6
	second antennal segment with small distal dark spot	first and second antennal segments more darkly pigmented
	Femora with two darker rings	Femora with one darker ring
	Abd. segm. 4–8 with spines on the lateral keels	Abd. segm. 4–8 with no spines on the lateral keels

It is noteworthy that the nymph of *T. vulnerata* shows close relationship with that of *Pyrrhosoma*, and the nymph of *T. sanguinalis* most with that of *Ceriagrion* of the Old World.

<sup>2</sup>After Klots (1932); not mentioned in the original description of Needham.



*Telebasis sanguinalis* Calvert. A, dorsal view of full-grown male nymph; B, right antenna; C, end of abdomen of female, left lateral view; D, mentum, inner side; E, right and left mandibles, inner side; F, end of abdomen of male, ventral view; G, left lateral gill; H, right lateral lobe of mentum.



***Acanthagrion adustum* Williamson (1916)**

Nymph (hitherto unknown), reared, Plate VI.

A small slender nymph with the gills as long as the abdomen. Living colors pale green with a fine middorsal black line, adult brownish.

Head broader than long, widest across the eyes, the eyes prominent and each eye with 5 dotted black stripes, the fourth stripe elevating the eye margin. Hind angles well developed, truncated, the outer corner spinulose, occipital border slightly excavated.

Antennae longer than head, 6-segmented with an indication of a seventh segment; pale, the basal segment and upper part of segment 2 darker and richly bristled. Relative length of the segments 19 : 22 : 28 : 20 : 11 : 12 (8 : 4). Labium broadly triangular, reaching backward to the middle coxae, the sides diverging, the distal inner half of each side with a row of six or seven small short setae. Only one mental seta on each side. Median lobe very prominent, uncleft, the border finely denticulated. Lateral lobes armed with four setae, movable hook large, end hook strong and curved downward; terminal border with four dents, the first and the last one respectively with the tips trifid and bifid.

Maxillae: left and right maxilla of the same structure. End hook large, with three smaller dents on its base, followed by six larger and six smaller setae below; upper margin with three large teeth, followed by six marginal and one lateral seta.

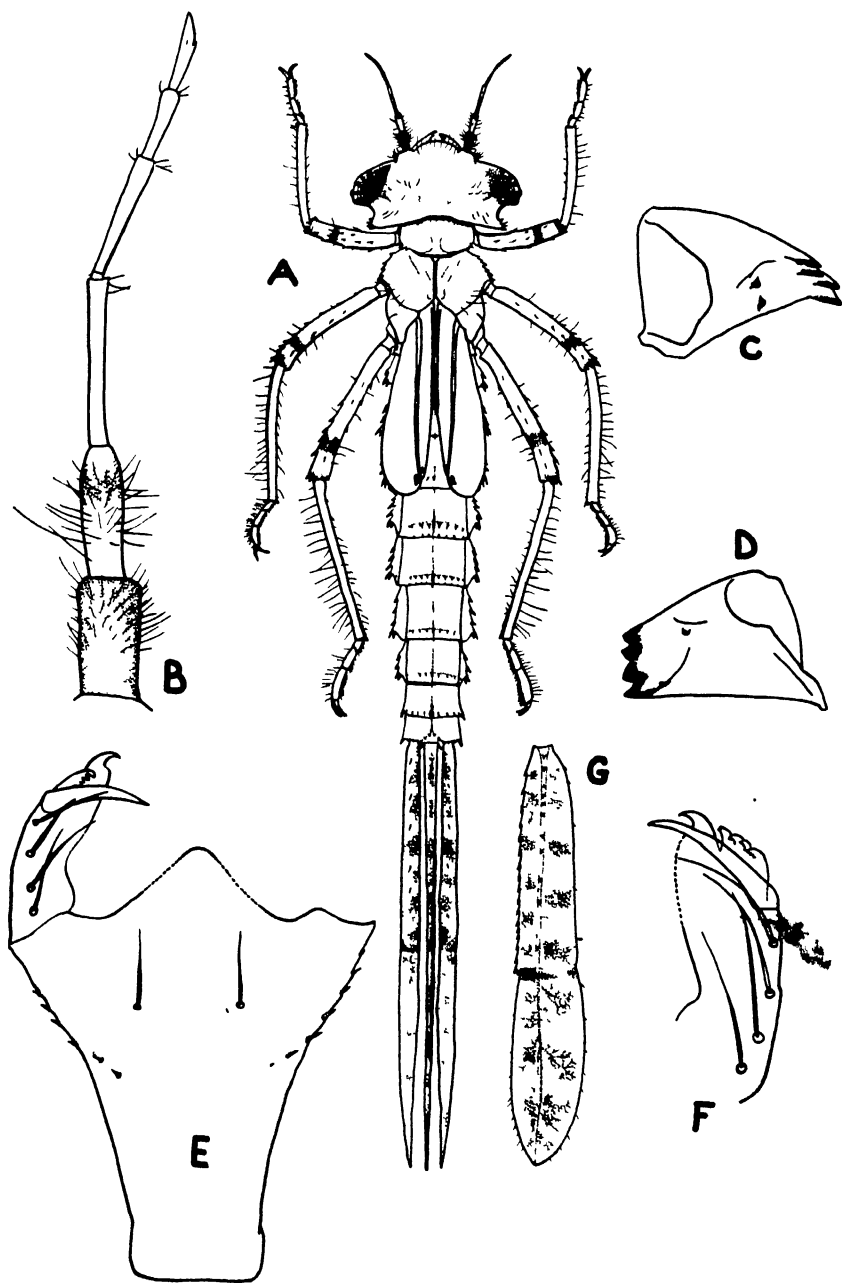
Mandibles with four unequally sized teeth, right mandible with a denticle at base of the largest dent and two teeth on the inner side, left mandible with one median and one marginal tooth on the inner side.

Hind lobes of prothorax and front margins of synthorax with a row of short spines. Wing pads reaching to anterior margin of abdominal segment 5. Legs pale, the femora with a darker ring in the apical half and at the apical end, covered with some rows of short spines and a few long fine hairs. Tibiae with many long fine hairs and with divided (trident) setae and some plumose setae at the apical end. Tarsi with plumose setae along the inner margin and with finer simple hairs on the outer side.

\* Abdomen cylindrical, tapering to the end. Lateral keel of segments 1-8 flattened and armed with five short spines. A fine black middorsal line over all the segments; ventral side pale with a black midventral spot on the hind margin of the segments.

Gonapophyses of female long, reaching to apex of segment 10; outer pair somewhat longer than inner pair, ventral margin of outer pair with a few hairs and with two short spines, apex long (about one-third the length of the gonapophyses), conical. Gonapophyses of male short, straight, sharp-pointed, directed caudad to middle of segment 10.

Gills very long and lanceolate, as long as the abdomen, apex acute; ventral margin in the basal half armed with a row of 18-19 short spines, dorsal margin with a few long hairs. Nodus indicated by a small constriction at about half the length of the gill, darkened



*Acanthagrion adustum* Williamson. A, dorsal view of full-grown female nymph; B, right antenna; C, left mandible; D, right mandible; E, mentum, inner side; F, right lateral lobe of mentum; G, left lateral gill.

below. Membrane with many pigmented areas, forming about 10 crossbands.

Total length, including gills, 18–20 mm., abdomen 6.5–7.0 mm., gills 6.5–7.0 mm., hind femur 2.5 mm. One male and one female examined.

Two nymphs of this species were found at Zandery I (27. V. 1941) in a small partly widened creek along the railroad in the savanna, where they were dredged from between the water plants (*Cabomba aquatica* Aubl.).

From the male nymph the imago appeared on June 1. No imagines have been observed at the collecting place. The reared male belongs to the darker form of the species, differing from the common color pattern as follows: nasus entirely black, post ocular spots blue, middle lobe of prothorax black without orange spots, synthorax above clear blue, not orange or reddish brown; a black spot on the second lateral suture, about one-half the width of the dorsal black stripe, reaching the metastigma. Segment 8 with basal two-thirds of dorsum black, dorsum of segment 10 black except blue hind margin. The morphological details, as penis and appendages, however, fully agree with the typical *adustum*, which has been collected near Zandery and Republiek.

This nymph greatly resembles the described *Acanthagrion* specimen from Brazil, Rio Grande Do Norte, Forêt d'Utinga 11. XII. 1935 (Cowley, 1939), but differs from it in the less excavated hind margin of the head, the spinulose front margin of the synthorax, and in the number and arrangement of hairs and dents on the maxillae (gills are lacking in the Brazilian specimen.)

### ***Acanthagrion indefensum* Williamson (1916)**

Nymph (hitherto unknown), reared, Plate VII.

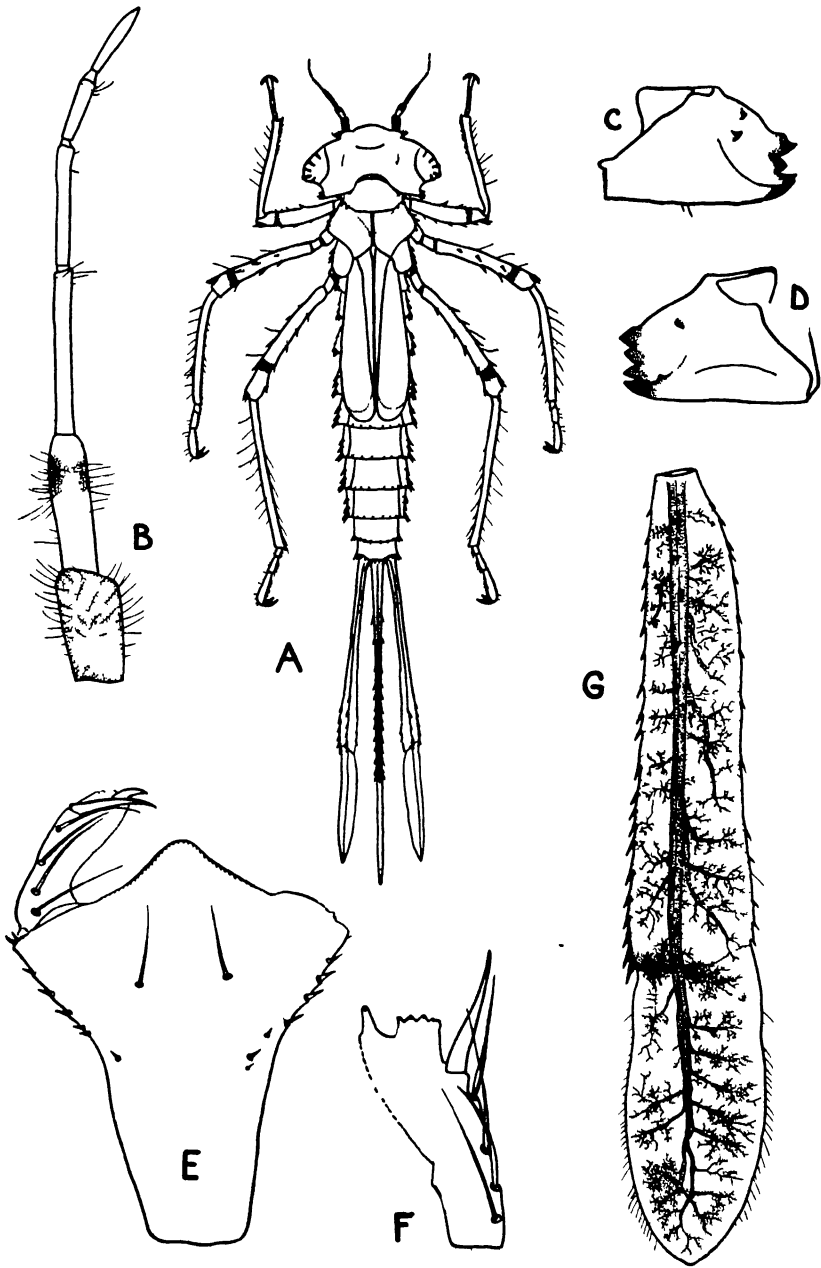
The nymph of this species is very similar to those of *A. adustum*, differing only in the following points:

Living colors green, with no darker markings. Antennae as long as or slightly longer than head, 6-segmented, the basal segment and upper end of segment 2 darker and bristled, otherwise pale and practically unbristled. Relative length of the segments 18 : 21 : 26 : 19 : 11 : 13.

Left maxilla with two small dents at base of end tooth, followed by five larger and seven smaller setae below; upper margin with three equally sized large teeth, followed by seven finer setae below; right maxilla, end tooth with two smaller basal teeth followed by four larger and eight more laterally situated setae; upper margin with three large equally sized teeth, followed by four longer setae and two smaller laterals.

Abdomen segments 5–10 with the hind margin dorsally spinulose; ventral margin of outer pair of female gonapophyses with four short spines, apex long (about one-third the length of the gonapophysis), conical, and sharp pointed.

Gills very long and lanceolate, as long as abdomen, with the apex nearly rounded; nodus at three-fifths the total length, well indicated; margin ventral to the nodus armed with a row of about 20 short



*Acanthagrion indefensum* Williamson A dorsal view of full-grown female nymph, B, right antenna, C, left mandible, D, right mandible, E, mentum, inner side, F, right lateral lobe of mentum, G, left lateral gill

spines, those on the nodus the largest; dorsal margin with about 15 finer setae. Sides of the gill apically to the nodus with a row of longer hairs. Membrane with many finely branched parts of the tracheal veins, which are more or less pigmented, but forming no distinct darker crossbands.

Total length, including gills, female 14–16 mm.; abdomen 5.5 mm.; gills 6 mm. One female nymph and one female exuvia examined.

Beside its smaller size, the nymph of this species is best characterized by the position of the nodus in the gill, situated in *adustum* at about one-half the length, in *indefensum* at three-fifths the length of the gill.

The specimens were collected at the same place as those of *A. adustum* on June 18, 1941. One of the females was reared, and emerged June 28.

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# LIFE HISTORY NOTES ON MICRATHYRIA (Odonata)

JAMES G. NEEDHAM,  
Cornell University, Ithaca, N. Y.

The nymphs of four species of this little known genus have recently come to hand. One of them, *M. hageni*, occurs within the limits of the United States. All four are West Indian, and all were reared by me during recent visits to these islands. The nymph of *M. dissocians* was well described and figured by Dr. Elsie Broughton Klots in her report on the Odonata of Puerto Rico of 1932, from specimens that I collected on the island in 1930. I wish to note at the outset that hers is the first description of a nymph of this genus; for the Brazilian nymph that I described in 1904 (Proc. U. S. Nat. Mus. 27: 211) along with the adult reared from it as "*Micrathyrta pallida*" n. sp. has been found to belong in the closely related genus *Erythrodiplax*.<sup>1</sup> I reared nymphs of *M. aequalis* in Cuba in 1937, and of *M. didyma* and *M. hageni* in Santo Domingo in 1940; these I now wish to describe and differentiate by means of keys. I will also add a few observations on the very unusual egg-laying habits of *M. aequalis*.

The adults of these species are readily distinguishable by the key furnished by Dr. Klots in her 1932 paper; the nymphs may be distinguished as follows:

## A KEY TO THE KNOWN NYMPHS OF MICRATHYRIA

1. Venter of abdomen pale, marked with a double row of brown dots or dashes... 2  
    Venter of abdomen obscure, without obvious pattern..... 3
2. These markings minute round dots; lateral labial setae nine or ten... **aequalis**  
    These markings larger transverse dashes; lateral labial setae eleven or twelve..... **didyma**
3. Abdomen on the dorsal side pale basally, blackish beyond the middle... **hageni**  
    Abdomen clouded, with a pair of submedian bands of brown..... **dissocians**

### *Micrathyrta hageni*

I begin with this species because of special personal interest in finding it. I tried to find it in Texas where it is recorded from the Rio Grande region. I got it in Santo Domingo, but only by collecting two nymphs and rearing one of them.

The place was a beautiful mountain pond near El Llano on the road to Puerto Plata across the northern coast range. The pond has a charming setting among green hills, with steeply rising grassy slopes and tree-crowned summits all around it. The water is clear (though it is in a pasture), and too deep for wading except near shore. The emergent vegetation is scanty, and the submerged water weeds are not

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<sup>1</sup>Dr. Fr. Ris (Libellulinae, de Selys Coll., p. 511) regarded my *M. pallida* as a synonym of *Erythrodiplax chloropleura*; but Dr. D. J. Borror, in a more recent study of the genus *Erythrodiplax* has restored it to good specific standing in that genus.

too thick for effective use of nets. It is a small pond, only a stone-throw wide, and but little longer. It is easy of access by a short walk from the road, but not visible from the roadway. It lies close to the top of the north range on the seaward side.

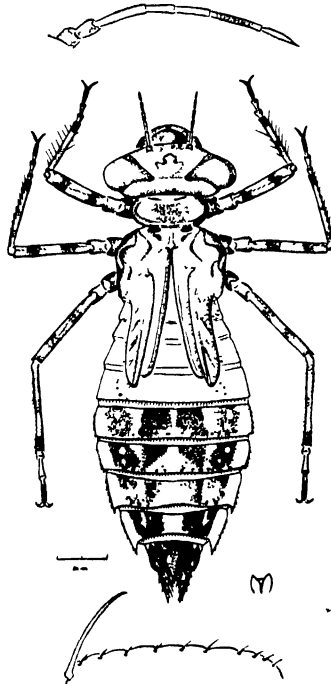
This pond was fairly swarming with dragonflies of many kinds. Most conspicuous was the big red *Tramea abdominalis*. Adults of this species were in the air everywhere, their cast skins besprinkled the shore line, and living nymphs swarmed in the weed beds. Three other ubiquitous skimmers were common enough: *Orihemis ferruginea*, *Pantala flavescens* and *Erythrodiplax umbrata*. But *Micrathyrus hageni* was very scarce, and the explanation of that scarcity probably lay in the abundance of the nymphs of these larger predators. In an hour and a half of collecting I took *Tramea* nymphs by the hundreds, while of the *Micrathyrus* I got but two.

I did not discover that I had taken the nymph of *Micrathyrus* until after I had left the pond, and I came by my reared specimen very unexpectedly. Dr. Julio Garcia Diaz was with me; the afternoon was waning; we were to be with friends in Santiago for dinner in the evening. We were hastening to make as complete a catch as possible in the limited time available. I plied my apron-net in the water, and dumped the unsorted catch of hundreds of specimens into a pail, and carried it back to our hotel in Santiago. Arrived there I noticed that one odd looking little black nymph was trying to climb up the side of the pail. Having a pillow cage handy, I put that nymph into the cage and set the cage back in the water. While I was dressing for dinner the adult emerged and expanded its wings. I put it into a paper bag to mature its colors and then went to dinner. The next morning I found I had a finely colored adult *M. hageni*, together with the whole cast skin from which it had emerged. The following description is based in part on that cast skin and in part also on a half grown nymph found later among the specimens in my pail.

The nymph measures 17 mm. in length; abdomen 12; hind femur 5; width of head 5, of abdomen 6.

This is a smooth greenish nymph, heavily marked with brown as follows: On the head is a mottled pattern; on the sides of the thorax a broad diffuse lateral band extends down over the leg bases and a dash of brown lies across the prothoracic dorsum. The wing cases when well grown are heavily washed with brown. The legs are mostly pale, with two rings of brown on the femora, three on the tibiae and a broader one on the last segment of the tarsi. There is on the sides a crescentic streak of brown under the base of each wing sheath. The abdomen is more or less suffused with brown; lightly on its basal half, and heavily from segment 5 to the end, but with an ill-defined and paler middorsal stripe, and a pale band near the lateral margin. The middle hinge of the labium extends backward to the base of the hind legs. The prominent middle lobe of the mentum is almost unarmcd. There are ten lateral and twelve mental setae. The relative lengths of the seven pale antennal segments are 4:6:9:7:8:10:10, the second and sixth are heavily marked with brown.

The half grown nymph taken at the same place and time is very similar but lacks the full complement of raptorial setae, these being laterals 9, mentals 11. In both specimens the abrupt blackening of the posterior half of the abdomen is very marked.



Nymph of *Micrathyrina hageni*

With enlarged antenna above, and end of lateral lobe of the labium below.

### *Micrathyrina aequalis*

This was the commonest Libelluline dragonfly present at Soledad, Cuba, in May, 1937. It swarmed about the edges of the big pond in the botanical garden and about two lesser ponds outside the garden. It is a low-flying species that does not stray far from the edge of its native pond. A bed of *Potamogeton natans* near the dam in the big pond of the garden was its favorite haunt. The seed spikes of this waterweed, rising stiffly erect out of the water for an inch or two, furnished its favorite perching places. The floating leaves of *Potamogeton* were selected by it for oviposition. On May 8th and 9th I made some observations on its egg-laying. The process was very different from that of any other Libelluline known to me.

The female oviposits unattended by the male. She alights on the edge of a floating leaf, squats on it crosswise with legs widely extended, and turns her abdomen downward and forward under it. Thus inverted the end of her abdomen is in proper position for sticking the eggs to



the leaf's under surface. She swings her body from side to side, plastering her eggs to the leaf in rather irregular rows and in a single layer, and leaving them there to hatch. From one position on the edge of a leaf the female is able to reach about half way across it. On about a square inch of one side of one leaf I counted and estimated about 2000 eggs. These may have been laid by more than one female; for she may move from leaf to leaf, and there may be repeating. However one female operating on a fresh leaf for about a minute laid 184 eggs by actual count, and then went elsewhere to continue laying.

Males hover around and sometimes interfere. I saw one male settle on the back of a busily ovipositing female. He took her by the top of the head with his claspers, and they flew away together. They remained together only for a moment, and she returned again to lay some more eggs.

I reared a nymph on May 7th, obtaining a fine male adult specimen. With its cast skin for guidance I was able to identify other nymphs which I collected in great abundance from a little pond back of Mr. Gray's residence just outside the garden.

The nymph measures in length 17 mm.; abdomen 9; hind femur 5; width of head 5, of abdomen 6.

This is a very pale, almost unpigmented nymph, blackish only on the eyes, on a band running inward from the front of the eye, and two streaks running inward from its inner hind angle. There is a faint mottling of the upper surface on the head and a faint longitudinal middorsal band on the prothorax. The antennae are pale except for the brown suffusing segments 1, 2, and 6. The legs show very faintly the usual cross banding and very conspicuously a fringe of long thin hairs.

The dorsum of the body is faintly besprinkled with pale brown prickles, that are most evident on the abdomen. There is a pair of roundish areas bare of these prickles on each abdominal segment with a little brown dot at the rear margin of each, and there is a similar bare patch at the front on each lateral margin.

The labium is armed with ten lateral and fourteen or fifteen mental setae. The lateral spines of the 9th abdominal segment are as long as that segment is on the middorsal line and the spines of 8 are but little shorter. The lateral appendages of the abdomen are about half as long as the inferiors and the superior is a little longer than the laterals. Segment 10 is narrowed almost to nothing on the middorsal line.

### ***Micrathyria didyma***

I collected both adults and nymphs of this species from the little weedy spring-fed brook that flows down Arroyo Sabana Miguel, near San José de las Matas, Santo Domingo. It was associated there with *Dytthemis rufinervis*, *Cannaphila funerea*, *Lestes spumarius*, *Leptobasis vacillans*, and others. I got a number of nymphs by raking the bed of the streamlet with a little sampling net, and I reared two of them, a male and a female. The dates were June 21st and 22nd.

The nymph measures in length 18 mm.; abdomen 12; hind femur 5; width of head 5, of abdomen 6.

This is a blackish nymph, with the skin everywhere heavily besprinkled with dark granulations that are coarser than in the other species, and approach solid blackness on the end of the abdomen. The pale antennae are broadly marked with blackish at the juncture of the two basal segments and on the middle of the third and sixth. The frons is brown, fenestrate with transverse streakings of paler color. On the rear of the head seven scurfy-pubescent longitudinal streaks of brown extend down the declivity of the occiput. The usual median longitudinal band of brown on pro- and mesothorax is narrowly divided by paler color.

The labium is armed with twelve lateral and fourteen mental setae. The lateral spine on the 9th abdominal segment is shorter than the middorsal length of that segment, and the spine on 8 is shorter still. The inferior abdominal appendages are very long and sharp (longer than 9 plus 10 middorsally); the laterals are a little less than half, the superior is a little more than half as long as the inferiors.

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MEDICAL PARASITOLOGY, by JAMES T. CULBERTSON. Pages xvi and 285, 16 figs., 22 full-page plates, 6 x 9 inches. Published by COLUMBIA UNIVERSITY PRESS, Morningside Heights, New York. 1942. Price, \$4.25.

In the preface to his book the author advises us that changing circumstances of modern times require that medical schools should give more instruction on the causes of parasitic diseases. Modern travel, business and the global war all enhance the possibility of spread of these infections into new areas. Professor Culbertson feels that our greatest hope of protection against these diseases is the dissemination of knowledge of the agents which cause them. His text carries this information to the medical student and physician. Its organization, manufacture and style are excellent. The reader gains a complete picture of the dynamic side of medical parasitology without being troubled by a mass of morphological and taxonomic details.

The text is written in two parts. Part One, General Considerations, is a masterful presentation of general information about parasitism. It seems to us that the strength of the book lies in this part. Part Two, Infections Caused by Animal Parasites, is a brief description of protozoan, helminth and arthropod parasites and the diseases caused by them. The emphasis in this section is placed upon the medical aspects of infections: methods of infection, symptoms, treatment and prevention. A short section on technical methods and references follows this part. The illustrations consist of photographs.

Two chapters are devoted to arthropods, one of 23 pages to insects and the other of 10 pages to arachnids, crustaceans and myriapods. Entomologists may find the treatment of these chapters somewhat disappointing, since keys, morphological descriptions and citations to literature are reduced to a minimum. However, we feel that the author has exercised good judgment in keeping his text simple for readers with a limited background in taxonomy and morphology.

—WILBUR M. TIDD.

# A DRAGONFLY NYMPH DESIGN ON INDIAN POTTERY

CLARENCE HAMILTON KENNEDY,

Ohio State University,  
Columbus, Ohio

In the U. S. Navy report to the 33rd Congress (1855), entitled "The U. S. Naval Astronomical Expedition to the Southern Hemisphere during the years 1849-1852," Vol. II, we find an article by Thomas Ewbank which bears the heading "Appendix E. A Description of the Indian Antiquities Brought from Chili and Peru by the United States Naval Astronomical Expedition." On page 130 Ewbank figures an Indian bowl or deep plate with a decorative design in which the zygopterous nymph is used as the motif. In the page of figures this item is lettered S.

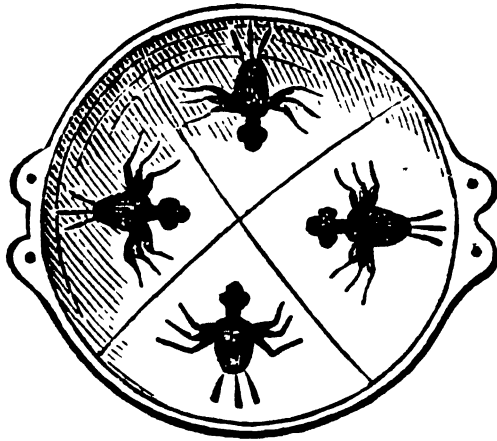
Ewbank (p. 132) writes as follows: "Figures s-y are specimens of thirteen plates or shallow pipkins, varying from three to thirteen inches across, and rarely exceeding half an inch in depth. Most have handles, terminating with the head of a bird, etc. All are ornamented within, none without. The colors are black, red, white, and yellow. Except such as have recurved or ring-shaped handles, all have studs at the rims; and some of these projections have small perforations, probably to insert loops of twine to suspend them against the walls, instead of resting them on shelves. Those marked s, t, were found in 1820 in a huaca (grave) near Saint Sebastian, one league from Cuzco."

The region is Incan but pottery from a burial might be pre-incan. The history of the Inca Empire is well known: at the time of the Spanish conquest it had been rather recently organized from several Andean tribes. The history of its tribes previous to the Empire, their origins and wanderings are more obscure. Cuzco was an Incan metropolis but its environs might have had previous cultures.

The design on this dish is the first instance we have found of a dragonfly nymph used as the motif in a repetitious design. Ewbank states that "figures s-y are thirteen plates varying from three to thirteen inches across." If all items have the same reduction, the plate or bowl (fig. s) with dragonfly nymphs is ten to twelve inches in diameter. The colors of this particular design are not given. The material collected by the Astronomical Expedition was deposited in the Smithsonian Institution and may be still there.

The creature from which the design was drawn is obviously a six-legged Arthropod, and because the three caudal appendages widen apically and it has large eyes it is probably a zygopterous nymph. If the three caudal appendages (gills) had been broad at the base and narrowed apically, it could have been an ephemerid nymph with appressed lateral gills. I do not know any zygopterous nymph with such a broad and short body but the nymphs of the Andean fauna are little known. If it had paired lateral abdominal gills it could be thorine, and might be such, as the paired gills of thorine nymphs are as

much under the sides of the abdomen as projecting beyond the sides. They might not be conspicuous from above in this species. Without lateral gills the next best assumption is that it may have been a very short Argia. Some of the nymphs in this genus are the shortest bodied nymphs of which we know at present. The crab-like sprawl suggests an inhabitant of swift mountain streams where to face the current the body lies tight on the rocky bottom. Swift water is further suggested in the wide horizontal spread of the legs which permits the tarsal claws to be deeply anchored in the substratum. It also lays the legs themselves flat on the bottom where least vibration from swift water can occur. Further yet the femora are very wide, probably streamlined in cross-section. The last is a character of swift-stream mayfly or stonefly nymphs rather than of dragonfly nymphs.



Indian bowl with dragonfly nymphs. From grave near Cuzco, Peru.

From Ewbank, 1855.

The question arises, why should a small obscurely colored water insect interest an artist-potter? I have no answer. In this connection of dragonflies as an art motif with Indian designers is the article by Hugh G. Rodeck, 1932, these *ANNALS*, 25: 688-690, 2 pls. In a hasty survey I have run across the butterfly in a very conventionalized form used in a repeating design on Indian pottery from the Pecos Valley, New Mexico. The reference is to d of fig. 34, p. 87, and fig. 33, p. 86, vol. I of "The Pottery of Pecos" by Kidder and Amsden, 1931, Phillips Academy Publication, Andover, Mass.

**THE NEARCTIC SPECIES OF PARASITIC FLIES BELONGING TO ZENILLIA AND ALLIED GENERA**, by WENDELL F. SELLERS. Published in *Proc. U. S. Nat. Mus.* 93: 1-108 (no illustrations). Paper bound. 1943.

This paper revises the genera *Zenillia*, *Phryxe*, *Carcelia*, *Aplomya*, *Sisyropa*, *Thelymyia* and a new genus, *Angusta*. It contains a few extra-limital species and another new genus, *Chrysophryxe* (Brazil). It has no illustrations.—C. H. K.

# ON THE NYSSORHYNCHUS COMPLEX

(Diptera: Culicidae)

CHARLES H. T. TOWNSEND,

Itaquaquecetuba, EFCB, São Paulo, Brazil

The utmost caution is requisite to success in dealing with the members of the Nyssorhynchus complex. There are thirty-five names that have so far been applied to them; these are listed below in alphabetical order.

<i>albimanus</i> Wd. 1821	<i>goeldii</i> RG 1941
<i>albipes</i> Th. 1901	<i>gorgasi</i> DK 1907
<i>albitarsis</i> LA 1878	<i>ininii</i> SA 1938
<i>allopha</i> LP 1921	<i>lanei</i> CA 1938
<i>anomalophyllus</i> Komp 1936	<i>limai</i> GL 1937
<i>aquacelestis</i> Curry 1932	<i>metcalfi</i> GL 1938
<i>aquasalis</i> Curry 1932	<i>nordestensis</i> GL 1938
<i>argyritarsis</i> RD 1827	<i>nuneztovari</i> Gab. 1940
<i>bachmanni</i> Petr. 1925	<i>oswaldoi</i> Per. 1922
<i>brasiliensis</i> Chagas 1907	<i>paulistensis</i> GLC 1937
<i>cubensis</i> Agr. 1900	<i>perezi</i> SP 1928
<i>cuyabensis</i> NP 1923	<i>pessoai</i> GL 1937
<i>darlingi</i> Root 1926	<i>rangeli</i> GGL 1940
<i>davisi</i> PS 1927	<i>rondoni</i> NP 1922
<i>dubius</i> Bl. 1905	<i>rooti</i> Brethes 1926
<i>emilianus</i> Komp 1941	<i>strodei</i> Root 1926
<i>evansi</i> Brethes 1926	<i>triannulatus</i> NP 1922

There may be synonyms among the above names, but any one of them may be needed at some future time if it can be definitely placed by means of type specimens. The name *tarsimaculatus* Gld. is omitted because it equals *albipes* Th. independently of types.

It is useless to accept synonymy in this complex before every last character both morphologic and physiologic of all stages has been exhaustively compared and found to be identical. Thus *bachmanni* may easily prove distinct from *triannulatus*, *aquacelestis* is not likely to be *oswaldoi*, *gorgasi* and even *albipes* may prove distinct from *albimanus*, *evansi* and *rooti* or even *cubensis* and *dubius* may prove valid.

Goeldi's and Dashkow's (Galvao and Lane, 1938, p. 173; Rozeboom and Gabaldon, 1941, p. 92) forms are not yet definitely placed.

Rozeboom (1941) gave a most useful compilation of what is known regarding the Caribbean anophelines. Rozeboom and Gabaldon (1941) gave a summary of the Nyssorhynchus complex and named the lower Tapajós form *goeldii*. Komp (1941) named the present dominant Belém form *emilianus*. Komp's article calls for the following comments.

We were well equipped on the Tapajós in 1932-1933 for dealing with the taxonomy of the Culicidae except that the work was cut short before completion (Townsend, 1934, p. 495), and we found there a virgin field

for investigation. Shannon had spent a week there the year before (June 14-20, 1931) and found *darlingi*, *albitarsis*, *goeldii* (which he called *tarsimaculatus*) and *bachmanni*. We found the same four forms and also *brasiliensis*, only these five being positively distinguished in numbers of adults, and *goeldii* being identified with query as *oswaldoi*. But we also found a few adults of what seemed to be *albimanus*, and these with larvae were so identified with query, while it was stated that the males might not belong to the females. Referring to our original notes made at the time on the Tapajós, the material doubtfully determined by us as *albimanus* comprised two males reared June 23 and July 4 from open ground pools; seven females on horse August 8-12; seventy larvae July 20 to August 7 from exposed river margin grass and ground pools, agreeing with *albimanus* characters. The mounts of the terminalia of the two males were accidentally spoiled and the June 23 one was discarded, the July 4 one being retained because it was the only remaining specimen. Thus only one mount should be in the U. S. National Museum, and that was or should have been labelled *albimanus* with query. No positive determination can be made from that mount. On tarsal coloration the males did not fully agree with the females, but both agreed on wing coloration and other characters. Stone determined this material as *gorgasi* with query. Pinto did not report on the July 4 male (lacking terminalia) and a female sent to him.

An *albimanus* race is definitely known to be present in Venezuela (Rozeboom, 1941, p. 100) and should therefore be present in Brazil. Theobald and Grabham (1905, p. 15) recorded as *albipes* what was probably this race from British Guiana and Brazil. Theobald positively determined Goeldi's material in a long series of this race as *albimanus*. There is no reason why this race of *albimanus* should not have extended down the coast of the Guianas and Brazil (Lane, 1939) to Belém forty years ago. It will be strange indeed if it be not yet found in the Amazonian region. Changed environment may easily have exterminated it at Belém. *N. albitarsis* was present at Belém forty years ago, as shown by Goeldi's data. It is not present there now, but is present on the Tapajós.

There is no possibility that *emilianus* is Goeldi's form. Goeldi's egg figure could not have been made from a shrivelled or distorted *emilianus* egg. The habits also disagree, since *emilianus* does not frequent houses even in the immediate vicinity of its breeding places and prefers horse to human blood. The description and identification of *emilianus* are of much interest as fixing the present dominant form heretofore confused with *oswaldoi* at Belém but it can not be the form with which Goeldi worked. Nor can *goeldii*, the present dominant *oswaldoi*-like form on the Tapajós, be his species, since the adult habits of *goeldii* are the same as those of *emilianus*. The larval habits of the two are contrasted, *emilianus* breeding in sunlit pools and *goeldii* in more shaded pools and river margins.

We must look to the Theobald Collection for the male terminalia of Goeldi's form, which should be closely allied to *albimanus*. This dictum may plunge the subject into greater confusion for the moment, but clarity will eventually emerge from this confusion.

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THE DUCKS, GEESE AND SWANS OF NORTH AMERICA. A vade mecum for the Naturalist and Sportsman. By FRANCIS H. KORTRIGHT, the illustrations by T. M. SHORTT. Pages viii+476, over 200 text figures, and 36 colored plates. 6x9 inches. Published by THE AMERICAN WILDLIFE INSTITUTE, Washington, D. C. Price, \$4.50.

This is one of the outstanding bird books, written for the layman, to appear in recent years. Written by a Canadian sportsman, it is dedicated to the Sportsmen Gunners and Naturalists of Canada and the United States, and should go far in promoting the conservation of waterfowl.

The first 64 pages of the book contain general information about waterfowl: family and subfamily characters, duck topography, a glossary, scientific nomenclature (teachers of entomology will like this section), moults and plumages, identification, determination of sex and age, mating and nesting habits, feeding habits, longevity, flight speed, hybridism, botulism and lead poisoning, migration routes and banding (by Frederick C. Lincoln), conservation (by Ira N. Gabrielson), and other water birds. Pages 65-379 contain "Descriptions, Identifications and Life Stories of the Ducks, Geese and Swans." Each of the 61 species and subspecies occurring in North America is discussed in considerable detail: the pronunciation and derivation of the scientific name, colloquial names, a detailed description of both sexes and all plumages, means of identifying specimens, field marks (on the water, in flight, and voice), and a "life story." The latter contains a discussion of the feeding, courtship, nesting, and other habits of the species, its range and migration, and its status as a game bird. Additional sections of the book deal with weights and measurements, bibliography, acknowledgments, index, and the color plates.

The illustrations in this book are superb. There is a distribution map for each species showing the principal breeding and winter ranges, over 200 line drawings in the text, and 36 color plates in the back of the book. The line drawings illustrate all the important structural characters of the various species and groups, and the appearance of each species on the water and in flight. The color plates illustrate all the plumages—adults in winter and breeding plumage, eclipse and autumn plumages, and the downy young. Each color drawing of a bird shows it in a standing position, and hence shows the underparts and feet. With each drawing of an adult bird is a drawing of its spread wing, a feature usually not included in most waterfowl plates. There is one plate of duck hybrids. The explanation of each plate includes not only a key to the figures, but often contains a discussion of the figures and a summary of the distinguishing characters of the species illustrated, and contains references to other color plates and the text pages dealing with the species. The illustrations in this book establish Mr. Shortt as one of the outstanding bird artists on the continent.

This book is one which not only every sportsman, but every naturalist, ornithologist, and bird enthusiast should possess. It is printed on a good grade of paper and is bound to stand considerable use. The author, artist, and publishers are to be congratulated on the publication of this outstanding book.—D. J. B.

# A SYNOPSIS OF THE PSOCIDS OF THE TRIBE PSYLLIPSOCINI, INCLUDING THE DESCRIPTION OF AN UNUSUAL NEW GENUS FROM ARIZONA

(Corrodentia: Empheriidae: Empheriinae)

ASHLEY BUELL GURNEY,

Bureau of Entomology and Plant Quarantine,  
U. S. Department of Agriculture

This paper was prompted by the discovery, in the Tucson Mountains of Arizona, of a new psocid which apparently has as its closest relative a cave-inhabiting species of western Europe. The Arizona species represents a new genus which is a noteworthy addition to our Nearctic fauna, and, because of a lack of published revisionary work, a synopsis of the tribe to which the genus belongs has been prepared. One of the more interesting species of Psyllipsocini is *Psyllipsocus ramburii* Selys, which occurs in houses both in Europe and the United States, and which is dimorphic, both short-winged and long-winged individuals being found in the same colony. The European genus *Prionoglaris* Enderlein, which is closely related to the new Arizona genus, is unusual among psocids in the lack of a lacinia in the adult, and a section devoted to mouth parts, especially those of these two genera, follows the main taxonomic part of the paper.

I am greatly indebted to R. A. Flock, of the University of Arizona, for supplying abundant material of the new genus. The generous cooperation of P. J. Chapman, of Geneva, N. Y., and Nathan Banks, of the Museum of Comparative Zoology, in the loan of specimens of *Psyllipsocus*, is acknowledged. One new species is based on specimens collected in Yucatan by A. S. Pearse of Duke University while on an expedition sponsored by the Carnegie Institution of Washington, and I appreciate his kindness in making the material available. R. E. Snodgrass very kindly assisted in the morphological study of the mouth parts.

The important characters of the tribe Psyllipsocini are given in more detail later, but the nature of the group may be briefly indicated by listing the following outstanding characters: Tarsi three-segmented; wings without a definite sclerotized stigma or covering of scales; vein M normally forked in both wings, in front wing with three branches.<sup>1</sup>

Unfortunately, the classification of the higher categories of the Corrodentia is rather unsettled, but the family Empheriidae and the subfamily Empheriinae of this paper correspond to the Empheridae and Empherinae of Banks (1929), and his family and subfamily keys are useful. The latter author did not treat categories lower than subfamily, in the case of the Empheriidae, and there is need for a tribal revision. *Empheria* Hagen, the type genus of the family, is based upon a fossil,

<sup>1</sup>The nomenclature of the wing veins employed in this paper is after Enderlein (1927 and other papers), but it should not be assumed that all interpretations are correct until the tracheation of a member of the Psyllipsocini has been studied.



and this and several related fossil genera require study before such a revision can be accomplished. Certain fossil psocids are mentioned later, in order to give a better understanding of the group involved, but this paper is primarily concerned with recent, living species. Students will find Karny's classification (1930) helpful, since he presents an arrangement of all psocid genera then described, and his generic complex called *Psyllipsocini* is the same as mine, although his treatment of subfamilies and families is unlike either the previously mentioned classification by Banks or those of Enderlein (1927) and Pearman (1936).

### THE TRIBE PSYLLIPSOCINI

Characters: Legs slender, tarsi three-segmented; ocelli usually present; wings fully developed or rudimentary, without a definite sclerotized stigma or covering of scales, often with some setae on veins but without extensive pubescence. Wings of long-winged specimens as follows: Venation definite and all principal veins reaching wing margin; front wing with three distinct branches of M; the cross vein between Rs and M of front wing basad of the forking of M; anal veins of front wing two in number, briefly or not at all separated at their apices and terminating in a common nodus at wing margin; hind wing normally with M forked; usually a closed cell in hind wing and one, sometimes two, closed cells in front wing.

The wing venation is distinctive, and there is little likelihood of confusion with psocids belonging to other groups. The fossil genera *Empheria* Hagen and *Bebiosis* Enderlein, both occurring in Prussian amber (see Enderlein, 1911), have a closed cell formed in the front wing by vein Sc similar to the closed cell anterior to vein R in the front wing of *Prionoglaris*. The former genera were rather widely separated from the *Psyllipsocini* by Karny (1930), but I suspect that close relationship actually exists, and, if so, the group would appear to be an ancient one. This seems likely, in view of the closely related and probably long isolated genera occurring in Europe and Arizona.

Members of this group occur in both hemispheres, but none are known from the Australian Region. Several species have been found in caves, and this fact is of interest because comparatively few cave-inhabiting psocids are recorded. For lists of psocids taken in caves and for discussions of the general aspects of the faunas of caves, the reader is referred to Jeannel (1926), LeRuth (1939), Pearse (1938), and Wolf (1934).

### KEY TO THE GENERA OF PSYLLIPSOCINI (BASED ON ADULTS)

1. Vein Sc of front wing fused with R for a short distance in apical half of wing so that a closed cell anterior to R is formed (figs. 14, 15), (only fully winged individuals known); segment 3 of antenna unusually long for the *Corrodentia*, longer than head. . . . . 2
- Vein Sc of front wing not fused with R in such a way as to make a closed cell anterior to R (figs. 13, 19), (short-winged individuals frequent, fig. 23); segment 3 of antenna of normal length, much shorter than head (world-wide). . . . . *Psyllipsocus* Selys
2. A well-developed lacinia (maxillary pick) present; legs without scales (western North America). . . . . *Speleketor*, new genus
- Lacinia absent; legs covered with scales (western Europe). *Prionoglaris* Enderlein

**Speleketor<sup>2</sup>**, new genus

*Generic Description*.—Eyes with many facets, posterior margins remote from occiput; three ocelli; antenna longer than body, without setae, segments from third to apex minutely annulated, segmentation poorly developed at apex, apparently more than 13 segments; segments of antenna immediately following second extremely elongate; clypeus well developed, tumid; mandibles asymmetrical, fitted for chewing; labium weakly sclerotized, palpi present; hypopharynx with well developed pharyngeal or postoral sclerite and ovoid ventral sclerites; maxilla with slender, toothed lacinia; maxillary palpus elongate.

Pronotum short, distinct from mesonotum; legs elongate, slender, without scales; apical spurs of tibiae 4-4-4; femora and tibiae with fine, setalike spines; tarsi with fine spines, no ctenidia; each claw with ventral seta near apex. Wings without setae, venation much as in *Prionoglaris* (figs. 14, 15); abdomen well developed, with differentiated genitalia; male genitalia largely concealed by subgenital plate; female with large, platelike gonapophyses.

*Genotype*.—*Speleketor flocki*, new species.

**Speleketor flocki**, new species

(Figs. 1-12, 15, 24-28)

*Male*.—General body form as in fig. 3; head in frontal view as in fig. 1; eyes prominent, posterior margins slightly anterior to level of posterior margins of lateral ocelli; clypeus much swollen, anterior margin broadly emarginate in ventro-frontal view. Antenna with segments 1 and 2 short, globose; segment 3 about as long as middle tibia; segments 4-6 each somewhat more than one-half as long as segment 3; following segments successively shorter and segmentation difficult to distinguish from annulations (fig. 9 of a portion of segment 5). Mandibles (figs. 11, 12, in dorsal view) heavily sclerotized, asymmetrically developed in molar region; apex of mandible compressed laterally, chisel-like, with a blunt, subapical tooth. Labium (fig. 2, in ventral view) with well developed median lobes bearing sclerotized apical areas sparsely clothed with minute, short setae; a poorly defined membranous sclerite dorsad of median lobes extending between them apically; palpus borne laterally, the apical segment directed anteriorly and with sclerotized apical area. Hypopharynx (fig. 5, in ventral view) with well developed postoral and ovoid sclerites (further described in later discussion of mouth parts). Galea of maxilla having several sclerotized regions as illustrated (fig. 4); lacinia (fig. 7) slightly irregular at truncate apex, a shoulderlike pre-apical tooth; cardo and stipes partly fused; basal segment of palpus subquadrate; segment 2 with irregular external margin bearing setae, remainder of segment more sparsely clothed with setae, a short spur near base; apical segment with numerous setae, a sensory area at apex.

Prothorax weakly sclerotized; meso- and metathoracic sclerites well indicated (fig. 3). Front femur somewhat more robust than middle

<sup>2</sup>From two Greek words meaning "cave" and "to inhabit."

and hind femora; front and middle femora subequal in length, hind femur slightly longer; front femur with 10-12 minute setalike spines along basal two-thirds of ventro-anterior margin and 1 or 2 well separated, long, delicate sensory setae on ventro-posterior margin; middle and hind femora naked except for sensory setae and sparse minute pile. Tibiae circular in cross section, ventral surfaces with numerous minute spines; middle tibia about three-fourths the length of hind tibia and slightly longer than front tibia. Tarsus with segment 3 unarmed; paired claws, each with curved ventral seta and irregular ventral margin just basad of seta attachment (fig. 8); arolium absent. Front tarsus with basal segment armed with about 7 ventral spines, one of them at apex; middle tarsus with segments slightly longer than corresponding segments of front tarsus and similarly armed; hind tarsus with segment 1 bearing 7-10 ventral spines and paired apical spurs; segment 2 with 2-3 ventral spines and paired apical spurs; each segment of hind tarsus noticeably larger than corresponding segment of middle tarsus.

Wings as illustrated (fig. 15), with some variation; one specimen has a crossvein between  $R_{4+5}$  and  $M_1$  of one hind wing, making a closed apical cell, other hind wing normal; one specimen has  $M_3$  of one front wing arising from base of  $M_2$ , other front wing normal.

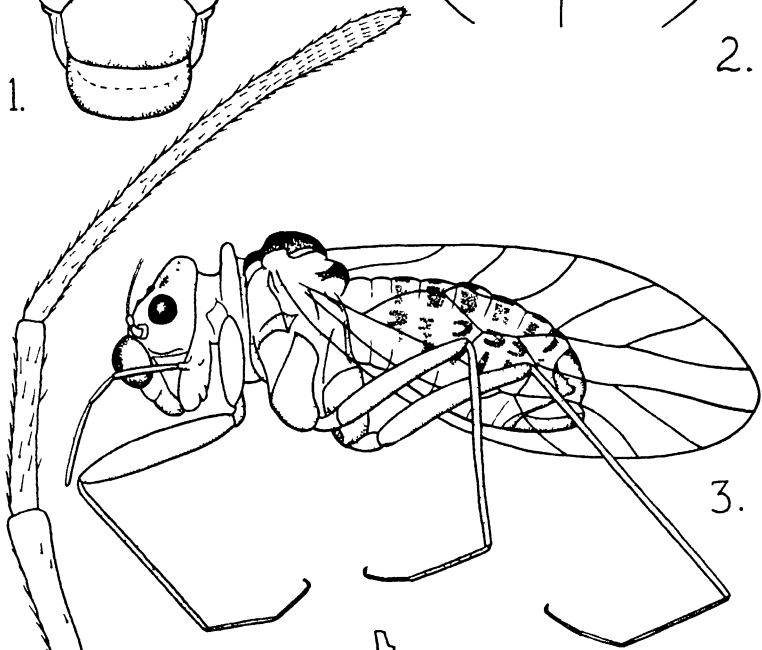
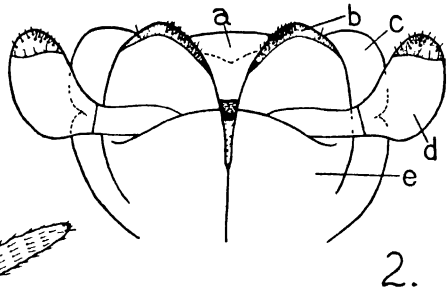
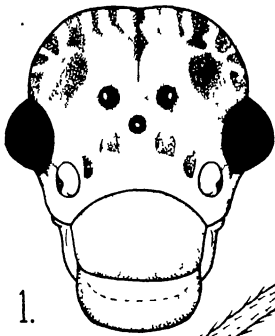
Abdomen robust, fleshy, 8 well marked segments anterior to genital segments. Terminalia: Supraanal plate broadly triangular and poorly defined; each paraproct an irregular oblong plate, with a circular nonsclerotized area in the dorso-lateral region, and an elongate nonsclerotized area in the ventro-lateral region, each of the areas bearing several setae; subgenital plate and associated structures in ventral view as in fig. 28; apex of plate broadly rounded, but laterally compressed so that it appears pointed in ventral view. Genitalia (figs. 27, 28) lying dorsad of subgenital plate, the rounded yokelike base visible through the transparent subgenital plate, the appendages imbedded in muscle and with extreme apices of apical arms visible dorsad near paraprocts.

Coloration: Head brownish, light and dark areas as in fig. 1; eyes and area surrounding each ocellus black; antennal segments 1 and 2 pale, flagellum light brown. Prothorax dirty white; meso- and meta-thorax with dorsal lobes dark brown, pleural sclerites light brown; front coxa pale, middle and hind coxae darker; femora fuscous in apical fourth; tibiae and tarsi pale. Wing membrane colorless; veins dark brown, those at apex of front wing and in apical and posterior parts of hind wing paler. Abdomen white, segments 1-8 marked with reddish brown as in fig. 3, a mid-dorsal row of spots, 3 lateral rows on

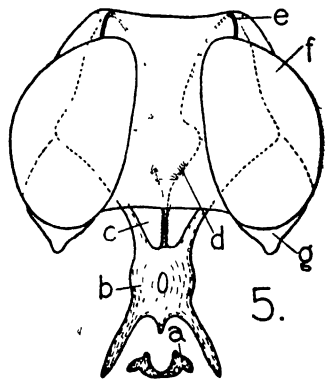
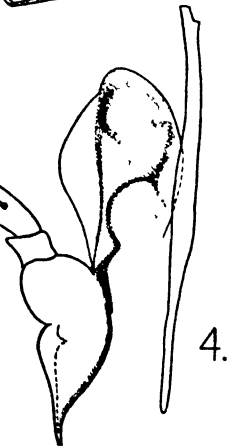
#### EXPLANATION OF PLATE I

*Speleketor flocki*, new species. Fig. 1. Female paratype, frontal view of head. 2. Female paratype, ventral view of labium. 3. Male paratype, general lateral view. 4. Female paratype, ventral view of right maxilla. 5. Female paratype, ventral view of hypopharynx.

(Figures 2, 5-7, 10, 16-18, 21, 22, 24-27, 29, 31, 32, 34, and 38 made with the aid of mercurochrome-stained, potash-treated, slide-mounted preparations; all drawings by the author.)



Spele-  
 ketor  
 flocki



each side; genital segments pale brown, more heavily sclerotized portions darker.

Measurements (of a representative specimen): Length of body 3.5 mm., of front wing 4 mm., of hind wing 2.4 mm., of hind tibia 1.9 mm.; width of head (including eyes) 0.9 mm.

*Female*.—Differing from male in terminalia: Apex of abdomen as in fig. 25 in ventral view; each gonapophysis convex, when pressed flat as in fig. 24; subgenital plate moderately sclerotized and rather poorly delimited, anterior margin with 2 short, blunt projections curving dorsad, posterior margin broadly emarginate.

Coloration and measurements as in male.

*Nymphs*.—Resembling adults in general body form; ranging from 2.7 mm. to 4.5 mm. in length. Front wing pads reaching about one-third the length of abdomen in stage preceding maturity, rudimentary in the smallest specimens. Hind tarsus of largest nymphs 3-segmented, front and middle tarsi 2-segmented with division of the apical segment poorly indicated; tarsi of small nymphs 2-segmented. Eyes of small nymphs much reduced in size, black and conspicuous. Antenna extremely elongate and setaceous, about 13 segments in larger specimens. Mandibles essentially as in adult; apex less elongate and chisel-like than that of adult; marginal flange of anterior third of molar region of right mandible not so fully developed as that of adult. Lacinia (fig. 6) strongly tridentate, shorter than in adult. Color pattern of head and abdomen similar to that of adult, particularly in larger nymphs.

*Type locality*.—Tucson Mountains, Ariz.

*Type*.—United States National Museum No. 55134.

*Holotype*.—Male collected March 2, 1941, by R. A. Flock.

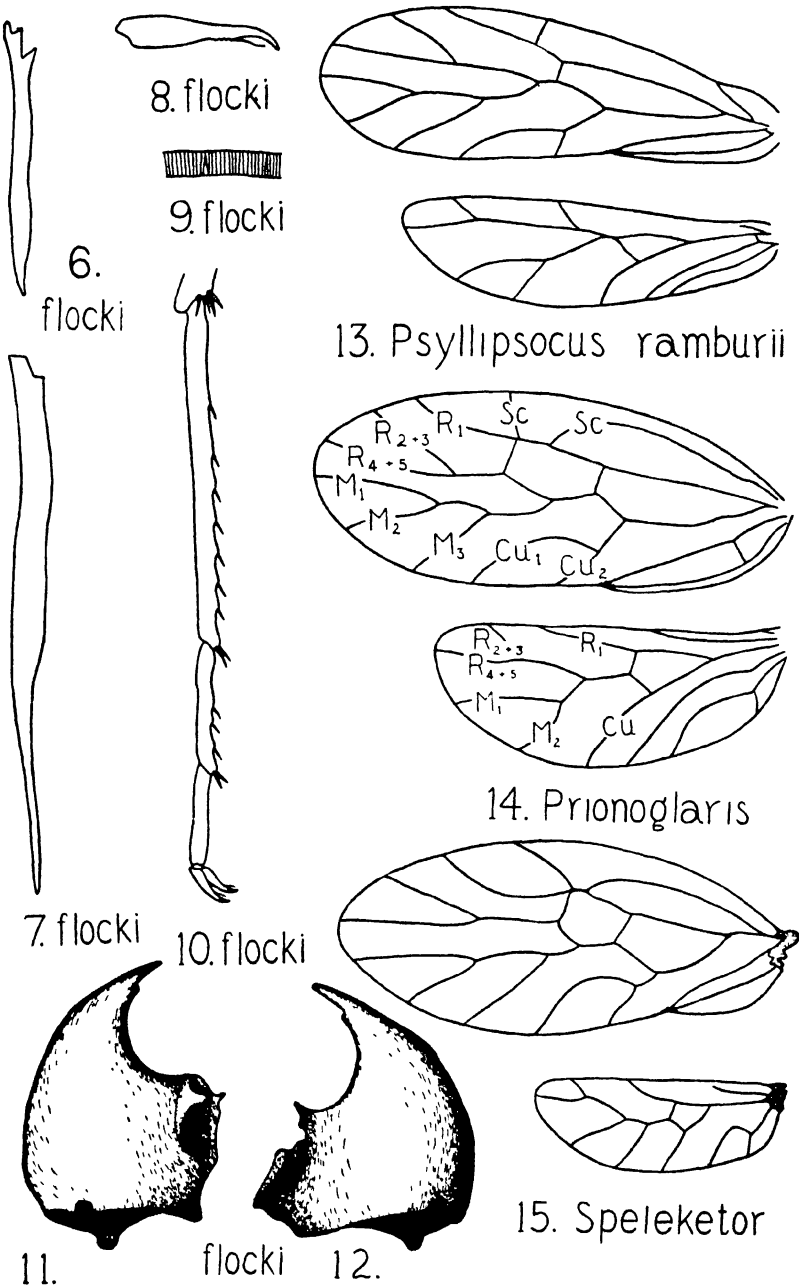
*Allotype*.—Female with same data as holotype.

*Paratypes*.—Forty-three males, 12 females, and 15 nymphs with same data as holotype; 1 male, 1 female, and 3 nymphs taken at type locality December 23, 1940. Of the above paratypes, collected March 2, 26 males, 2 females, and 7 nymphs are returned to Mr. Flock; 1 male and 1 female are deposited in the Museum of Comparative Zoology, Cambridge, Mass.; 1 male and 1 female in the collection of P. J. Chapman, Geneva, N. Y.; 2 males and 1 female and 1 nymph in the Illinois Natural History Survey, Urbana, Ill.; 1 male and 1 female in the Academy of Natural Sciences of Philadelphia. A few additional specimens from the type locality, not considered paratypes, have been dissected for slide mounts and other special preparations.

#### EXPLANATION OF PLATE II

Figs. 6-12. *Speleketor flocki*, new species. 6. Nymphal paratype, ventral view of right lacinia. 7. Female paratype, ventral view of right lacinia. 8. Male paratype, claw from hind tarsus. 9. Female paratype, small section of segment 5 of antenna. 10. Female paratype, lateral view of right hind tarsus and apex of tibia. 11. Male paratype, dorsal view of left mandible. 12. Same specimen as in fig. 11, dorsal view of right mandible.

Fig. 13. *Psyllipsocus ramburii* Selys, wings (after Enderlein, 1927, fig. 29). 14. *Prionoglaris stygia* Enderlein, wings (after Enderlein, 1919, fig. 21). 15. *Speleketor flocki*, new species, female paratype, wings.



The Genus *Prionoglaris* Enderlein

*Prionoglaris* Enderlein, 1909, Arch. Zool. Expt. Gén., Sér. 5, T. 1, p. 533. Genotype, *Prionoglaris stygia* Enderlein, 1909 (monotypic).  
*Scoliopsyllopsis* Enderlein, 1912, Zool. Anz., Bd. 39, p. 304. Genotype, (*Scoliopsyllopsis latreillei* Enderlein, 1912) = *Prionoglaris stygia* Enderlein, 1909 (monotypic).

*Prionoglaris* is closely related to *Speleketor*, differing as follows: Lacinia absent in adult; mandibles undergoing change from nymph to adult, with marked reduction of molar region; postoral sclerite of hypopharynx very differently shaped from that shown in fig. 5; legs covered with scales.

It is uncertain how much generic significance should be attached to the differences in wing venation (figs. 14, 15) and to several other features mentioned below, but certain of them, as the differences in the forking of vein M of the hind wing, are probably of more than specific value. The maxillary palpus of *Prionoglaris*, illustrated by Badonnel (1931), is much shorter than that of *Speleketor*. A well sclerotized aedeagus, unlike anything known in *Speleketor*, is figured by Ball (1936). As described and figured by Enderlein (1909), the nymph of *Prionoglaris* has a large, almost subquadrate pronotum, in dorsal view, in contrast to the very short pronotum of *Speleketor*. Although the much larger eyes of *Prionoglaris*, which extend to the posterior margin of the head in both nymph and adult, are noticeably different from those of *Speleketor*, generic significance is questionable because of the known variation found in *Psyllipsocus*. According to Ball (1936), the legs of nymphs in *Prionoglaris* are densely covered with microtrichiae; legs of adults are entirely covered by small plaques in the form of imbricated scales, each scale with four to six longitudinal grooves; there are no microtrichiae in the adults. Each tarsal claw has a strong preapical tooth in the nymph; the adult claw is untoothed, but shows preapical thickening.

Figs. 21 and 30 of Enderlein (1919), showing left and right wings of *stygia*, respectively, differ in the absence of a cross vein between the anal veins of the front wing as shown in fig. 30, though it occurs in fig. 21.

The wing venation and antennae ally *Prionoglaris* and *Speleketor* closely, but the differences mentioned above are so striking that to assign an Arizona species to a genus known only in western Europe would be unwise.

*Prionoglaris stygia* was described by Enderlein (1909) from 15 specimens (later shown to be nymphs) collected in a cave in the Pyrenees in 1907. The adult was later described (Enderlein, 1912) as *Scoliopsyllopsis latreillei* from a single female collected by Latreille, and labelled Paris, in the Selys Collection. The type of *latreillei* is illustrated in color by Enderlein (1919). The body length of the dried type is 4 mm., the length of the front wing 5.7 mm. As a result of rearing nymphs to maturity and examining the type of *stygia*, Ball (1936) showed the two genera to be based upon the same species. Badonnel (1931) had previously made *Scoliopsyllopsis* the basis of a new family, the Scoliopsyllopsidae. Though Karny (1930) placed *Scoliopsyllopsis* in the Psyllipsocini, he did not recognize *Prionoglaris* as the same and placed it in a special subfamily containing only the one genus.

In Belgium, LeRuth (1939) found specimens of *stygia* in all the caves reported; it was abundant and in one cave several hundred specimens were taken. The insect showed preference for inclined areas on the walls, there remaining motionless, but fleeing rapidly when disturbed. It was found in light zones of entrance galleries, as well as farther back in the caves.

### The Genus *Psyllipsocus* Selys

- Psyllipsocus* Selys, 1872, Ent. Mo. Mag., vol. 9, pp. 145-146. Genotype, *Psyllipsocus ramburii* Selys, 1872 (monotypic).  
*Nymphopsocus* Enderlein, 1903, Zool. Anz., Bd. 27, p. 76. Genotype, (*Nymphopsocus destructor* Enderlein, 1903) = *Psyllipsocus ramburii* Selys, 1872 (monotypic).  
*Parempheria* Enderlein, 1906, Stett. Ent. Zeit., Jahrg. 67, H. 1, pp. 306-307. Genotype, (*Parempheria sauteri* Enderlein, 1906) = *Psyllipsocus sauteri* (Enderlein) (new combination) (new synonymy) (monotypic).  
*Ocelloria* Weber, 1906, N. Y. Med. Jour., vol. 84, p. 885. Genotype, (*Ocelloria gravynymphia* Weber, 1906) = *Psyllipsocus ramburii* Selys, 1872 (new synonymy) (monotypic).  
*Ocellataria* Weber, 1907, Ent. News, vol. 18, p. 189. Genotype, (*Ocellataria gravynymphia* Weber, 1907) = *Psyllipsocus ramburii* Selys, 1872 (monotypic).  
*Fila* Navas, 1913, Rev. Real Acad. Ci. Madrid, T. 12, p. 332. Genotype, (*Fila vestigator* Navas, 1913) = *Psyllipsocus ramburii* Selys, 1872 (monotypic).  
*Fabrella* Lacroix, 1915, Bull. Soc. Ent. Fr., p. 194. Genotype, (*Fabrella convexa* Lacroix, 1915) = *Psyllipsocus ramburii* Selys, 1872 (monotypic).

**Generic Description.**—Much like *Speleketor*, except in the characters noted here. Eyes with posterior margins remote from or near occiput; 3 ocelli usually present, sometimes vestigial or absent in short-winged individuals; antenna with 22-30 segments, about as long as body, no segments extremely long; clypeus less tumid than in *Speleketor*; wings fully developed, with distinct venation, or much reduced, with rudimentary venation, never with closed cell anterior to vein R, a few fine setae sometimes present on veins (see figs. 13, 19, 35).

The apical spurs of the tibiae are apparently 4-4-4, but these characters of several species have not been described. A subapical tooth on each tarsal claw is present in all species except possibly *sauteri*. The tarsal claws of *sauteri* were originally described as lacking apical teeth and this was given as a generic character of *Parempheria*. *Parempheria minutissima*, a closely related species, was later described by Enderlein (1920), and, since Takahashi (1938) has reported a minute tooth near the apex of each claw, it is possible that the tooth occurs in *sauteri*. In *ramburii* and *yucatan* the tooth is so minute as to be overlooked unless examined very carefully. This tooth is different from the strong subapical setae of *Speleketor*. Pearman's statement (1924) that 13-segmented antennae occur in *ramburii* was probably due to an abnormal specimen or to an oversight, as the number is most often 26.

Variation in wing venation, and the presence, at least in *ramburii*, of both short-winged and long-winged individuals, have been largely responsible for the extensive generic synonymy. Reuter (1904) was the first to suggest, after finding specimens referable to both *Nymphopsocus destructor* and *Psyllipsocus ramburii* in the same colony, that only one species was present, and Tullgren (1909) concluded, after careful com-



parisons of both forms collected in houses in Stockholm, that *Nymphopsocus* was only a short-winged form. Pearman (1935) described his observations, made over a period of some months, of two colonies living in a building under undisturbed conditions; in each colony adults of both types appeared at intervals, though at times only the *Nymphopsocus* type occurred. He also found individuals, such as he illustrated (1924), with wings intermediate in length between typical short-winged and long-winged forms. Jentsch (1938, p. 32) has also noted specimens of intermediate wing length, and similar material from Massachusetts, New York, and Virginia is in the National Museum. In view of these observations, which have been generally accepted by Badonnel (1938) and other recent writers, there is no doubt regarding the synonymy of *Nymphopsocus*. Enderlein (1909) stated that anal spines (two strong spines, one of which is the larger, on each paraproct; see fig. 17) were absent in *Psyllipsocus*, though present in *Nymphopsocus*. Pearman (1935) has found spines in *Psyllipsocus*, but mentions that in one individual examined they were weakly developed. I have found a noticeable size difference in the spines of the left and right paraprocts of the same specimen (short-winged) from Massachusetts, so a considerable amount of normal variation is evident.

The variation of the wing venation of *ramburii* (genotype of *Psyllipsocus*) illustrated by Enderlein (1903c, pl. 11) and others shows that the venation of *sauteri* (genotype of *Parempheria*), illustrated by Enderlein (1906), does not warrant generic separation. The extent to which normal variation in psocid wing venation may occur is shown by Enderlein (1908b) in a study of *Psoquilla*. The margins of the wings of *sauteri* are said to have pubescence in the form of many rows of fine hairs, while the veins have a single row. Occasional setae occur on the wing veins of *ramburii*. Examination of *yucatan* with the higher power of a compound microscope (magnification of about 250 diameters) discloses minute, sparsely distributed setae and also regularly occurring groups of longitudinal, parallel lines on the wing margin. The occasional setae could easily give the erroneous impression that the lines are setae, some of which extend perpendicular to the wing margin. Minute spicules occur on the wing veins. The pubescence described by Enderlein as a generic character of *Parempheria* is probably of such a nature, or a closely similar one, and probably is sufficiently widespread in this whole group of species as to be of little generic value. Although the claws of *Parempheria* are described as untoothed, minute teeth are said by Takahashi (1938) to occur in *Parempheria minutissima*, so the reported absence of a tooth in *sauteri* is questionable.

*Ocelloria* was probably proposed inadvertently,<sup>3</sup> since it was done simply by the use of the name in connection with an illustration and was not mentioned in the text of the paper. The same habitus illustration was used by Weber the following year when describing *Ocellataria* in a formal way. The types of *Ocellataria gravinympha* are short-

<sup>3</sup>It is unfortunate that new names were proposed by Weber (1906), as they have not been catalogued or included in nomenclators. In addition to the name *Ocelloria gravinympha*, a new specific name in the genus *Clothilla* (which is a synonym of *Trogium*; see Gurney, 1939) was introduced by associating the name *Clothilla ocelloria* with an illustration of what is clearly *Trogium pulsatorium* (L.).

winged specimens of *ramburii*. Pearman (1928, p. 212) placed *Ocellataria* as a synonym of *Nymphopsocus*, which in turn is a synonym of *Psyllipsocus*. Chapman and Nadler (1928) treated *Ocellataria* as a synonym of *Nymphopsocus*, and used the combination *Nymphopsocus gravinympa* Web. That *Fita* and *Fabrella* were each based on long-winged specimens of *ramburii* is suggested by illustrations accompanying the original descriptions; the synonymy was indicated by Badonnel (1935).

Of the Old World species referable to *Psyllipsocus*, only *ramburii* (which also occurs in the New World) is sufficiently well known to permit its inclusion in a practical key, and the key that follows is limited to the described American species. Jentsch (1939, p. 116) has recently mentioned two females of a species of *Parempheria* found in 1928 in packing material about orchids that were believed to be from Venezuela. Very likely this species and others yet to be discovered in tropical America are members of *Psyllipsocus* as here treated. In the absence of a complete key, it is hoped that the following notes on Old World species will be helpful.

Enderlein (1909) described *Nymphopsocus troglodyta* from caves in France and Spain, and a variety, *algericus*, from Algeria. They are short-winged and said to be very closely related to *destructor* (synonym of *ramburii*), differing in the absence of ocelli and in the minute, cross-hatched structure of the abdominal body wall. The variety *algericus* was described as possessing spots of reddish pigment in the place of ocelli, the ocellar area of typical *troglodyta* being uncolored. Badonnel (1935) treated the latter as *Psyllipsocus* (*Nymphopsocus*) *troglodytes*, suggested that it might be a form of *ramburii*, but provisionally treated it as distinct. Jeannel (1926), Wolf (1934), and LeRuth (1939) treated *troglodytes*, and Wolf listed *algericus* as a distinct species.

Three species of *Parempheria*—*sauteri* (Japan), *metamicroptera* (Formosa), and *minutissima* (Hawaii)—were described by Enderlein in 1906, 1908a, and 1920, respectively. Reasons for considering *Parempheria* a synonym of *Psyllipsocus* have already been given. As described, *sauteri* differs from both *oculatus* and long-winged specimens of *ramburii* in having a more elongate and flattened cell  $Cu_1$  (cell formed by  $Cu_1$  and  $Cu_2$  with the posterior margin of wing, often called the areola postica) of the front wing. It is a larger species than *yucatan* and the apical discal cell of the front wing is differently shaped in the two species. The hind wing of *metamicroptera* was figured by Enderlein (1908a); it has no closed cell, which may be owing to a considerable reduction in length. The front wing is apparently much like that of *sauteri*. Whether the described condition of the hind wing is normal is unknown, but Enderlein had seven specimens, and apparently the reduction in size and venation was constant. The species should be known as *Psyllipsocus metamicropterus* (End.) (new combination). *Parempheria minutissima* is reported by Takahashi (1938) to be rather common in dwellings in Formosa, and he has enlarged upon the original description. The wing venation is very much like that of *sauteri*, but *sauteri* is larger than *minutissima*. The correct name becomes *Psyllipsocus minutissimus* (End.) (new combination).

Cockerell (1916) described the fossil *Psyllipsocus banksi* from Burmese amber.

A specimen of *Psyllipsocus* belonging to the Museum of Comparative Zoology has been examined that bears the following data: "Piti, Guam, Nov. 2, 1936, in food cupboard, O. H. Swezey, collector." Additional material is needed for adequate study, but several characters suggest relationship to *P. yucatan*.

#### KEY TO THE AMERICAN SPECIES OF PSYLLIPSOCUS

1. Apical segment of maxillary palpus tapering at apex, broadly rounded on inner margin (fig. 22), (both short-winged and long-winged individuals; males unknown), (Europe and North America)..... **ramburii** Selys  
Apical segment of maxillary palpus broad, apex more or less oblique (figs. 34, 36), (only long-winged individuals known), (southern part of North America)..... 2
2. Eyes especially prominent (fig. 40); apical segment of maxillary palpus with apex weakly oblique (fig. 36); male subgenital plate without conspicuous heavily sclerotized lateral margins, an elongate median structure on dorsal surface (figs. 38, 39); larger species..... **oculatus**, new species  
Eyes moderately prominent (fig. 37); apical segment of maxillary palpus with apex strongly oblique (fig. 34); male subgenital plate with conspicuous, heavily sclerotized lateral margins, a circular median structure on dorsal surface near apex (figs. 29, 30); smaller species..... **yucatan**, new species

#### *Psyllipsocus ramburii* Selys<sup>4</sup>

(Figs. 13, 16, 17, 20, 22, 23, 32)

*Psyllipsocus ramburii* Selys, 1872, Ent. Mo. Mag., vol. 9, pp. 145-146.

*Nymphopsocus destructor* Enderlein, 1903, Zool. Anz., Bd. 27, p. 76.

*Ocelloria gravonymphia* Weber, 1906, N. Y. Med. Jour., vol. 84, p. 885, (new synonymy).

*Ocellataria gravinympa* Weber, 1907, Ent. News, vol. 18, pp. 189-194, (new synonymy).

*Fila vestigator* Navas, 1913, Rev. Real Acad. Ci. Madrid, T. 12, p. 333.

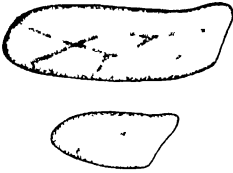
*Fabrella convexa* Lacroix, 1915, Bull. Soc. Ent. Fr., p. 194.

*Short-winged Female* (males of *ramburii* unknown).—General appearance as in fig. 23. Head with posterior margin much wider than prothorax; frontal view as in fig. 20; ocelli reduced, distinct. Maxillary palpus (fig. 22) with apical segment elongate, very differently shaped from corresponding segment in *yucatan* or *oculatus*

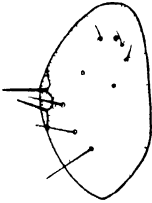
<sup>4</sup>The specific name of this species of often spelled with one *i*, but Selys (1872) used the double *i* and this orthography should be followed, as has been done by Pearman (1935). Opinion 8 of the International Commission on Zoological Nomenclature states that in such cases the original spelling is to be retained.

#### EXPLANATION OF PLATE III

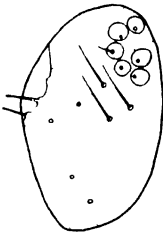
Fig. 16. *Psyllipsocus ramburii* Selys, short-winged female, wings. Port Washington, N. Y., September 20, 1937. 17. Same, short-winged female, right paraproct. Cummington, Mass., June 1, 1941. 18. *P. yucatan*, new species, female paratype, right paraproct. 19. Same, male paratype, wings. 20. *P. ramburii* Selys, short-winged female, frontal view of head. Cummington, Mass., June 1, 1941. 21. *P. yucatan*, new species, female paratype, supraanal plate. 22. *P. ramburii* Selys, short-winged female, ventral view of right maxilla. Cummington, Mass., June 1, 1941. 23. Same, general dorsal view of short-winged female. Cummington, Mass., June 1, 1941. (Femora foreshortened.)



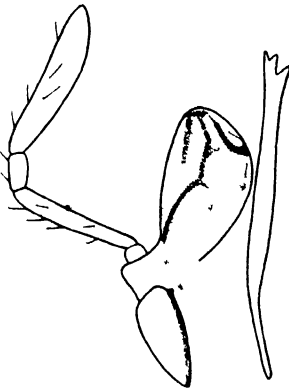
16 ramburii



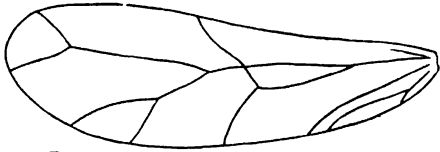
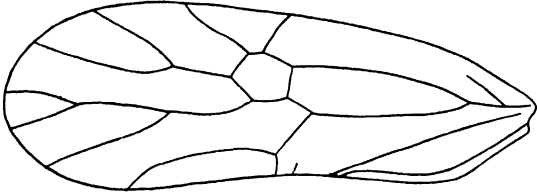
17 ramburii



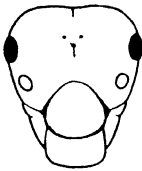
18 yucatan



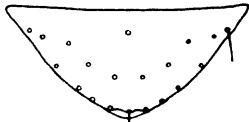
22 ramburii



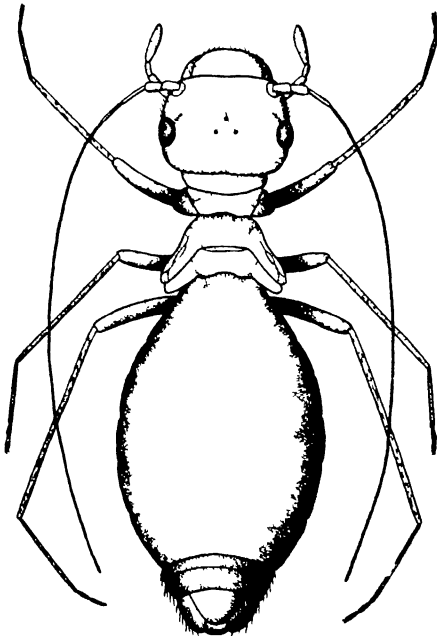
19 yucatan



20 ramburii



21 yucatan



23. ramburii

(figs. 34, 36); galea broad, marked by sclerotizations as illustrated; lacinia apically tridentate. Hypopharynx differing from that of *Speleketor* in the more nearly square shape of postoral sclerite and larger hypopharyngeal brush. Apical segment of labial palpus considerably broader than median lobe, in contrast to proportions in *Speleketor* (fig. 2). Mandibles of same type as those of *Speleketor*; subapical tooth of each mandible more prominent than that of corresponding mandible of *Speleketor*; notch of dorsal margin of molar region of right mandible occupying more of molar face than that of *Speleketor* and differently shaped; tooth of dorsal margin of molar region of left mandible more broadly rounded and less elongate than that of *Speleketor*. Antenna with about 26 segments. A distinct, poorly sclerotized neck region (largely concealed when head is retracted). Wings of variable length, usually as in fig. 16; veins broad and rudimentary; small but well developed setae occasional on veins and margins of front wing, rare on hind wing. Femora slender (somewhat foreshortened in fig. 23). Proportions of femur, tibia, and first, second, and third tarsal segments of front leg of a representative specimen as 3 : 4 : 1.6 : 0.5 : 0.6; of hind leg, 4 : 6.7 : 2.8 : 0.5 : 0.6.

Segmentation of abdomen not clearly visible, setae minute and scarcely noticeable with binocular microscope (magnification of about 70 diameters or less) except near apex, numerous minute setae visible with compound microscope. Genitalia much like those of *yucatan*, differing in details as illustrated. Paraproct with sparsely distributed strong setae; sensory area near base of paraproct (end toward supraanal plate) less noticeably developed than in *yucatan*, with numerous small setae; two spines of variable size borne on a ridge near margin of inner side, the basal one the larger, often much more conspicuously so than in fig. 17, in such cases easily seen with binocular microscope. Gonapophysis (fig. 32) with heavily sclerotized supporting structure extending about one-half distance from base to apex, lateral areas less sclerotized than apical region; egg guide closely associated near inner margin.

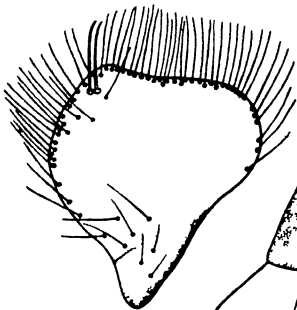
Coloration: General color dirty gray. Eyes brown; ocelli and a short oblique line extending anteriorly and mesally from each eye reddish; antenna whitish; dorsal region of thorax, a small area at base of first tergum, apex of abdomen, and legs darker gray, as illustrated (fig. 23).

Measurements (of representative specimen): Length of body 2 mm., of head in direct frontal view 0.55 mm., of hind tibia 0.75 mm.

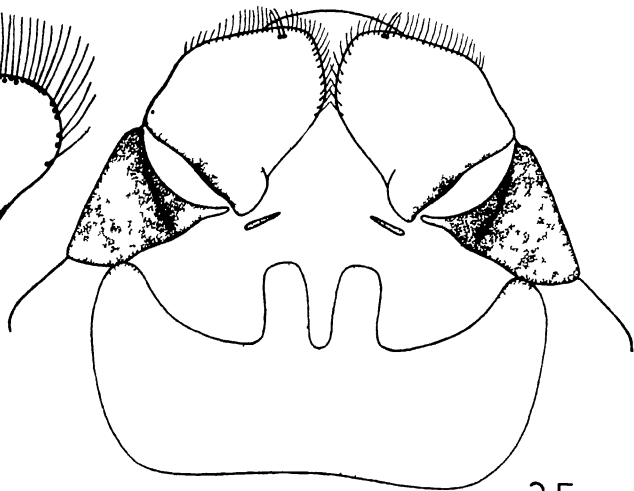
*Long-winged Female*.—Differing from short-winged form in more swollen thoracic region and in larger ocelli and eyes, the latter somewhat remote from posterior margin of head. Wing venation most often as in fig. 13, but variable (see Enderlein, 1903c, pl. 11), especially

#### EXPLANATION OF PLATE IV

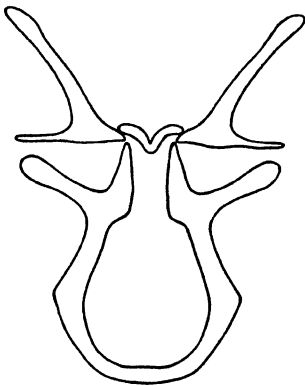
*Speleketor flocki*, new species. Fig. 24. Female paratype, right gonapophysis. 25. Female paratype, ventral view of apex of abdomen. 26. Female paratype, right paraproct. 27. Male paratype, genitalia. 28. Male paratype, ventral view of apex of abdomen.



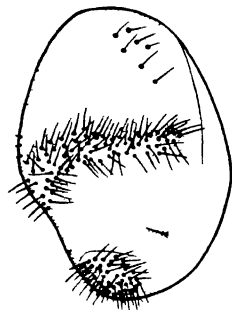
24.



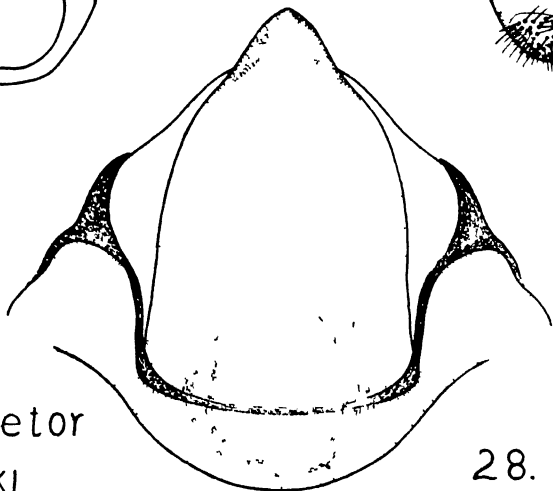
25.



27.



26.



28.

Speleketer  
flocki

as regards the position of vein M and the presence or absence of a crossvein forming a second discal cell of front wing similar to that in *yucatan* and *oculatus* (figs. 19, 35) (when present, cell practically rectangular, more like that of *oculatus* than that of *yucatan*); vein  $R_{4+5}$  of front wing briefly forked at apex in one specimen examined; vein M of hind wing variable in two Virginia adults, in one wing of each unforked. Massachusetts specimens show considerable variation;  $R_{2+3}$  and  $R_{4+5}$  of front wing are sometimes fused or connected by a crossvein; one specimen has no closed cell in the hind wing; another has  $R_s + M$  of hind wing abnormal, a second closed cell being formed.

Coloration: About as in short-winged form; wings immaculate.

Measurements: No apparent differences between short-winged and long-winged specimens examined; length of front wing of representative specimen from New York 2 mm., greatest width of front wing 0.7 mm.

*Nymphs*.—Immature specimens varying from slightly less than 1 mm. to 2 mm. in body length have been studied. Ocelli absent and eyes minute; apex of lacinia tridentate. Wings absent in smaller specimens, present as pads in larger ones. Tarsi two-segmented. Entire body whitish except for reddish eyes and apices of mandibles and laciniae. Certain nymphs were described by Weber (1907) as bright yellow.

Jentsch (1940) found that nerves going to the ocelli of short-winged specimens are reduced in size, compared with those of long-winged specimens. The number and length of the ommatidia in short-winged specimens are also less. These structures were illustrated by Jentsch.

*Biological Notes*.—Although recorded by Jentsch (1938) and several earlier writers from various locations within houses, such as on walls, beneath carpets, in staircases and almost any available cracks, *ramburii* shows preference for humid conditions, as evidenced by its discovery in caves by LeRuth (1939) and Badonnel (1938). Weber (1907) reared the species for three seasons in a cellar, and found it on wine jugs and barrels, a situation comparable to the vinegar barrels from which my Massachusetts collection was made. Badonnel (1938) found the presence of moisture necessary when rearing *ramburii* in cardboard boxes. His specimens were strongly attracted to a drop of water, but, after approaching a drop to the point of touch, they were repelled, and death resulted if they became engulfed in the water. Badonnel's captive specimens ate flour eagerly, and attempted to eat starch, sugar, paper, and cotton, but these materials did not appear satisfactory, and best rearing results were obtained in cages where the green mold, *Penicillium*, was abundant. Some cannibalism was noted, unhatched eggs and dead nymphs being eaten. Badonnel concluded that *ramburii* is polyphagous, but that molds constitute a normal item of diet.

The eggs, described by Pearman (1928), are laid individually and are not covered by a web or crusty coating as is the case with many Corrodentia. Each egg is "ellipsoidal, sculptured with tiny, alternately ranked, papillaceous processes," white, and very delicate. One female observed by Badonnel laid 21 eggs in 20 days, on some days laying as

many as five eggs, on others none. Weber (1907) reported that eggs, glued fast in cracks and other favorable places, hatch in 8–10 days, according to conditions. At 20–21° C. eggs under observation by Badonnel hatched in 18–19 days, at 25–26° C. in 14–15 days. Weber was apparently confused in his interpretation of the various members of a colony, as he recognized three nymphal stages and males as well as females. Although the types of *gravinympha* were said to include two males and a female, only females are present on the type slide in the National Museum, and no males of the species are known. Badonnel's short-winged specimens passed through five nymphal stages; fully winged individuals or those with wings of intermediate length had six. Factors responsible for the full development of wings are not known, though the possibility of fluctuations in temperature being involved is suggested by Badonnel. One individual, reared from a third-instar nymph, matured with front wings typical of the short-winged form and hind wings reaching half the length of the abdomen. Observations in England by Pearman (1935) indicate that long-winged forms may be most numerous in the latter part of the summer, and my collecting suggests that this is also true in Massachusetts. Pearman (1928) says that two generations are produced annually and the winter is passed in the nymphal condition. One might suspect, however, that the uniform conditions of certain caves or cellars would occasion little interruption of continuous breeding activity.

With the exception of Weber's redescription of the species from Pennsylvania, which was cited in Banks' catalogue of 1907, *ramburii* was not recorded from America until listed, both as *Psyllipsocus* and *Nymphopsocus*, from several localities in Brooklyn and New York City by Chapman and Nadler (1928). Nathan Banks writes (in litt.) that two specimens from Albany, N. Y., are in the Museum of Comparative Zoology.

The species is not known to be destructive, though said by Laing (1924) to be swarming among books and papers in a basement in London, England. Both Laing (1932) and Reuter (1909) feel that *ramburii* lends itself to ready transportation in commerce, and it may eventually be found widely distributed in the United States, occasionally appearing in such numbers as to be a nuisance.

*Material examined* (all females).—Cummington, Mass., on vinegar barrels in cellar of house, June 1, 1941, A. B. Gurney, 7 adults and 26 nymphs of short-winged form; same locality, July 20, 1941, 6 long-winged adults, 1 adult of intermediate wing length, 32 short-winged adults, and 10 nymphs of short-winged form; Port Washington, N. Y., September 20, 1937, L. D. Luey, 8 adults and 3 nymphs of short-winged form; Brooklyn, N. Y., in cellar, July 25, 1926, A. M. Nadler, 2 long-winged adults, 2 short-winged adults, and 11 nymphs, mostly of long-winged form (P. J. Chapman Collection); New York, N. Y., in cellar, May 17, 1925, A. M. Nadler, 1 long-winged adult (P. J. Chapman Collection); Woodside, N. Y., in apartment, M. Pollock, May 29, 1936, 1 adult of intermediate wing length and 1 nymph; Lancaster, Pa., July, 1904, slide bearing cotypes of *Ocellataria gravinympha* Weber, 3 short-winged adults (second specimen from label here selected as lectotype), United States National Museum Type No. 52355 (through



confusion with an accession number, incorrectly given in Weber's description as 46,844); Falls Church, Va., July 5, 1941, abundant in a dry, well-lighted basement of a house, A. R. Evers, 2 long-winged adults, 2 adults of intermediate wing length, 12 short-winged adults, and 12 nymphs of short-winged form. Except as otherwise noted, all the above material is in the United States National Museum.

***Psyllipsocus yucatan*, new species**

(Figs. 18, 19, 21, 29-31, 33, 34, 37)

*Psyllipsocus* (near *ramburii* Selys), 1938, Pearse, Carnegie Inst. Wash., Pub. 491, p. 238.

Pearse recorded the present material from Chichen Itza, Yucatan, following my tentative identification.

*Male*.—Head (fig. 37) with eyes reaching posterior margin of head, not prominent laterally; frontal suture conspicuous posterior to ocelli; lateral sutures not noticeable; maxilla (fig. 34) with apical segment of palpus enlarged apically, the terminal margin strongly oblique, thus differing markedly from *ramburii* (fig. 22). Wings extending well beyond apex of abdomen, venation (fig. 19) scarcely varying in material examined, in one specimen vein  $R_1$  of hind wing arising from  $R_2+M$  distad of discal cell. Abdomen weakly sclerotized except at apex; supraanal plate broadly triangular (fig. 21), sparsely covered with setae; paraproct (fig. 18) irregularly oval in outline, sensory area and anal spines near inner margin as illustrated. Apex of abdomen as in fig. 30 in ventral view; subgenital plate longitudinally divided at base, lateral areas conspicuously delimited by strongly sclerotized marginal supports, tapering to a moderately sclerotized blunt apex; slender paired arms of genitalia visible through base of subgenital plate and projecting anteriorly in body; dorsal view of subgenital plate as in fig. 29 when dissected, genitalic arms arising from irregular, roughly circular, well sclerotized structure.

Coloration: Body pale straw-colored; eyes brown; ocelli reddish; heavily sclerotized portions of mouth parts and genital segments dark brown; wing membrane faintly tinged with fuscous, a clear spot at posterior margin of wing between apex of  $Cu_2$  and apices of anal veins; wing veins pale.

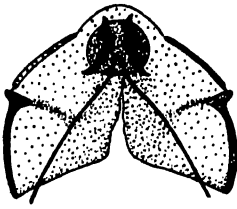
Measurements (of representative specimen): Length of body 1.15 mm., of hind tibia 0.5 mm., of front wing 1.25 mm.; greatest width of front wing 0.42 mm.

*Female*.—Essentially like male except for genitalia and somewhat greater size. Apex of abdomen as in fig. 33 in ventral view; each

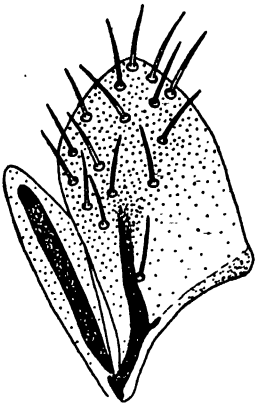
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EXPLANATION OF PLATE V

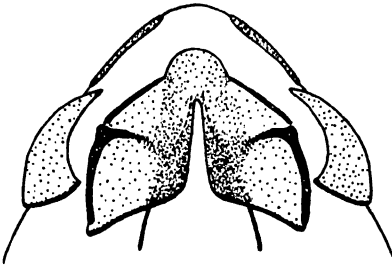
Fig. 29. *P. yucatan*, new species, male paratype, inner view of subgenital plate and genitalia. 30. Same, male paratype, ventral view of apex of abdomen. 31. Female paratype, right gonapophysis and egg guide (drawn to nearly twice the scale of fig. 32). 32. *P. ramburii* Selys, short-winged female, right gonapophysis and egg guide. Port Washington, N. Y., September 20, 1937. 33. *P. yucatan*, new species, female paratype, ventral view of apex of abdomen. 34. Same, female paratype, ventral view of right maxilla.



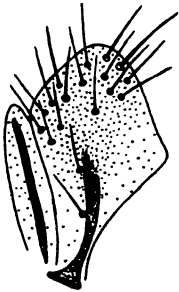
29. yucatan



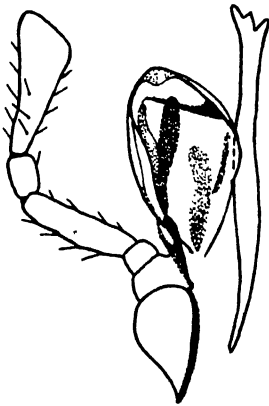
31. yucatan



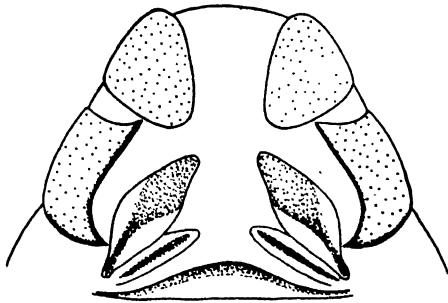
30. yucatan



32. ramburii



34. yucatan



33. yucatan

gonapophysis with more heavily sclerotized portions conspicuous, less sclerotized parts not clearly visible, in special preparation (fig. 31) very similar to that of *ramburii*; subgenital plate broadly rounded at apex, noticeably sclerotized only at apex; supraanal plate and para-proct as in male.

Coloration: As in male.

Measurements (of representative specimen): Length of body 1.3 mm., of hind tibia 0.5 mm., of front wing 1.3 mm.; greatest width of front wing 0.45 mm.

*Nymph.*—There are three nymphs, ranging from 0.8 mm. to 1.1 mm. in body length. They closely resemble adults in structure and color; wing pads of the larger nymphs extend one-half the distance to the apex of the abdomen.

*Type locality.*—Xtoloc Cenote Cave, Chichen Itza, Yucatan.

*Type.*—United States National Museum No. 55651.

*Holotype.*—Male collected in bat feces, June 24, 1936, by A. S. Pearse.

*Allotype.*—Female with same data as the holotype.

*Paratypes.*—One female and 3 males mounted on slides, and 2 males, 2 females, and 3 nymphs preserved in alcohol, all with same data as holotype. Several special dissections are on slides. One of the above slide-mounted males is deposited at the Museum of Comparative Zoology, Cambridge, Mass.

### ***Psyllipsocus oculatus*, new species**

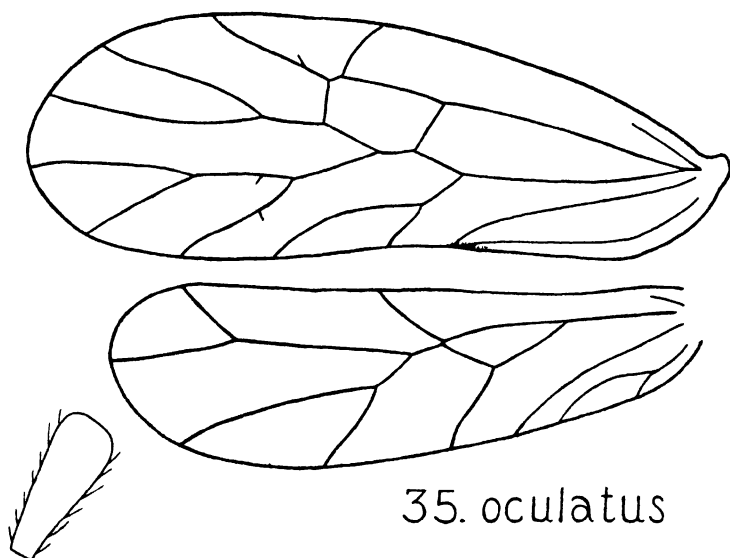
(Figs. 35, 36, 38–40)

*Male.*—Head (fig. 40) with prominent eyes; lateral arms of frontal suture visible; lacinia, galea, and length proportions of palpal segments of maxilla similar to those of *yucatan*; apical segment of palpus (fig. 36) with apex blunt, broadly rounded, the apical margin weakly oblique. Apical third of wings projecting beyond apex of abdomen; venation as in fig. 35, an occasional small seta on veins. Apex of abdomen in ventral view with sclerotized portions of apical terga and subgenital plate as illustrated (fig. 39); margins of subgenital plate weakly sclerotized and incurved so as to be unnoticeable until dissected and stained, main portion of disk moderately sclerotized and with no such thickened supporting margins as characterize *yucatan*, base undivided, apex weakly sclerotized; dorsal view of subgenital plate as in fig. 38 when dissected and flattened, weakly sclerotized marginal areas visible, a longitudinal, broadly lanceolate, heavily sclerotized median structure as illustrated, from near the base of which slender, well sclerotized genitalic arms arise.

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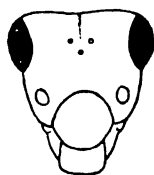
#### EXPLANATION OF PLATE VI

Fig. 35. *Psyllipsocus oculatus*, new species, male holotype, left wings. 36. Same, male holotype, ventral view of apical segment of right maxillary palpus. 37. *P. yucatan*, new species, male paratype, frontal view of head. 38. *P. oculatus*, new species, male holotype, inner view of subgenital plate and genitalia. 39. Same, male holotype, ventral view of apex of abdomen. 40. Same, male holotype, frontal view of head.

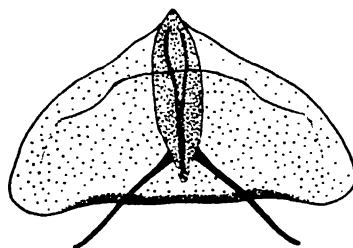


35. oculatus

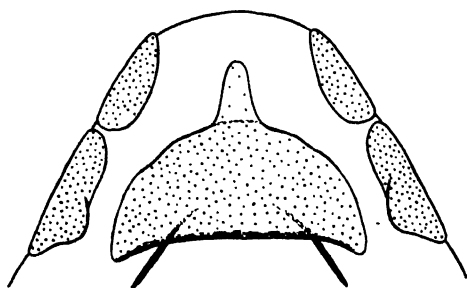
36. oculatus



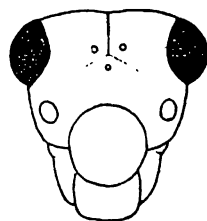
37. yucatan



38. oculatus



39. oculatus



40. oculatus

Color: Head a darker shade of straw color than in *yucatan*; eyes brown, margins black; ocelli pale; remainder of body and legs about as in *yucatan*; wing membrane barely tinged with fuscous, immaculate.

Measurements: Length of body 1.5 mm., of hind tibia 0.6 mm., of front wing 1.5 mm.; greatest width of front wing 0.6 mm.

*Type locality*.—Mexico.

*Type*.—United States National Museum No. 55652.

*Holotype*.—Male collected by C. P. Trotter, of the Bureau of Entomology and Plant Quarantine, on the international bridge, Laredo, Tex., June 7, 1940, with geranium plants in soil, found in baggage from unknown locality in Mexico.

Only the type is known, and description from an uncertain locality would be unwise, were the species not being treated in a comprehensive study which shows that *oculatus* clearly belongs to the same stock as *yucatan*.

#### NOTES ON MOUTHPARTS, WITH SPECIAL REFERENCE TO SPELEKETOR AND PRIONOGLARIS

An elongate, rodlike, often forked lacinia is usually considered a distinctive structure of Corrodentia, developed in no other insects except certain genera of Mallophaga. Because it is separated from the main body of the maxilla, unlike the lacinia of typical chewing insects, the lacinia of psocids was poorly understood by most early authors and its homologies uncertain (see Snodgrass, 1905). Muscles, nerves and other kinds of evidence recently have demonstrated that the "maxillary fork" is actually a modified and detached lacinia, as has been pointed out by Badonnel (1934, pp. 73-84). This view had been adopted earlier by Enderlein, but the proofs had not been fully demonstrated. Little information is available on the function of psocid laciniae. Pearman (1928, p. 268) was unable to verify the suggestions that had appeared concerning their use, and thinks that they may serve as supporting props or levers during the act of biting with the mandibles. Figs. 6 and 7 show the nymphal and adult laciniae of *Speleketor*.

An unusual feature of *Prionoglaris* is that the lacinia is lacking in the adult except for a membranous remnant. Badonnel (1931) first noticed this peculiarity, but had only one adult for study, whereas Ball (1936) had a series of nymphs and adults which enabled him to be certain of the absence of the lacinia in the adult and to compare nymphal and adult structures carefully. Although lacking in the adult, the lacinia is well developed in the nymph, at the apex sclerotized and quadridentate.

Ball (1936) has also described and illustrated the mandibles of *Prionoglaris*. Those of the nymph are of a typical chewing type, quadridentate in the incisor region, with the molar region well developed and transversely grooved. In contrast, the adult mandibles are extremely curved, long and tapering in the incisor region, the internal margin being finely denticulated; the molar region is simpler than that of the nymph. No changes of such an extent in mandibular shape occur in *Speleketor*.

Weber (1936), Cope (1940), and others have illustrated the labium of several psocids, and Badonnel (1931) has figured that of *Prionoglaris*, but the differences in structure found in various genera, coupled with differing interpretations, have not permitted the homologizing of all the labial structures of *Speleketor*. In ventral view (fig. 2) the labial palpi (*d*) are seen to originate at the apical margin of a ventrally convex prementum (*e*). The submentum is basad of the prementum. Each median lobe (*b*) is well developed and much more heavily sclerotized than a lateral expansion (*c*) of the same plate that is easily overlooked in all except stained preparations. Between the median lobes and dorsad of them is a weakly sclerotized lobe (*a*) which bears a posteriorly directed dorsal flap. The definite recognition of glossae and paraglossae has not been made in *Speleketor*.

Badonnel (1931) has illustrated the hypopharynx of *Prionoglaris*, and, since it is considerably different from that of *Speleketor*, it is important to describe this organ of the latter genus rather fully in order to emphasize the value of the hypopharynx in classification. Fig. 5 is a ventral view of the hypopharynx of *Speleketor* after treatment with caustic potash and stain, but the same structures are visible in an alcoholic specimen. Posteriorly, there is a well sclerotized postoral sclerite (*b*) which has diverging posterior arms for attachment and similar anterior extensions that serve to strengthen each side of the main anterior portion or lingua (*c*) of the hypopharynx. The postoral sclerite is convex on its ventral surface and there is a small hole as illustrated. Dorsally it is concave. In special preparations a small sclerite (*a*) appears attached by membranous connections to the postoral sclerite, but before dissection the small sclerite is located on the roof of the mouth in the epipharyngeal region of the clypeus and directly dorsad of the postoral sclerite. A small conical development of the epipharynx, associated with the small sclerite mentioned, is not sufficiently sclerotized to show well in a caustic potash preparation. The lingua (*c*) is weakly sclerotized and has a pair of chitinous filaments running its entire length. The filaments are strongly undulate as illustrated, and along the inner margin of each, near the base of the undulation, there is a group of setae (*d*) known as the hypopharyngeal brush. Ventrad of the lingua is a pair of large ovoid sclerites (*f*) borne on the weakly sclerotized extension of the lingua which curves ventrally and then posteriorly. The chitinous filaments (*e*) may be traced, just below the surface of the lingua, as they follow the curve from the dorsal surface of the lingua to the ventral surface of the hypopharynx where the ovoid sclerites occur. Each filament goes to the respective ovoid sclerite, and, in lateral view, it may be seen to extend along the lateral margin of the sclerite. Each ovoid sclerite is strongly convex ventrally and bears a small sclerite (*g*) at its posterior apex which serves as a point of attachment.

Badonnel (1931) states that the chitinous filaments of *Prionoglaris* are strong and rigid, differing from the long and supple ones of typical psocids (and of *Speleketor*). His figure of the postoral sclerite shows the shape of that structure to be very different from that of *Speleketor*, and the lingual region of the hypopharynx is also different.

The function of the parts of the psocid hypopharynx has been poorly understood for many years, but is now better known, owing to the researches of Badonnel, H. Weber, and others. Earlier authors, such as Snodgrass (1905), believed the chitinous filaments to be ducts and the ovoid sclerites lingual glands. Cope (1940) has recently adopted a modification of this view, maintaining that the ovoid sclerites are reservoirs connected by ducts to the postoral sclerite, which he regards as derived from a salivarium. While this view may be correct, Cope has not satisfactorily shown that the ovoid sclerites are not simply specialized thickened parts of the ventral region of the hypopharynx, as Badonnel (1934) believes. In a later paper, Badonnel (1936) discusses the ovoid sclerites and their connections in detail. Weber (1933, pp. 58-59; 1936, and other papers) described the postoral sclerite as a cup with its concave dorsal surface fitted to receive a plunger situated dorsad of its opening and operated by the huge muscles of the clypeus. His figures show that the structures function as a mortar and pestle. Food particles are considered to pass along the dorsal surface of the hypopharynx, between the molar regions of the apposable mandibles, to the cup, where further mastication occurs. From the cup the food goes to the pharynx and thence to the oesophagus. If this opinion be correct, the previously mentioned conical structure on the epipharynx of *Speleketor*, situated dorsad of the postoral sclerite, probably acts as a plunger or pestle for grinding food particles in the cup.

### SUMMARY

The tribe Psyllipsocini includes *Psyllipsocus* Selys, *Prionoglaris* Enderlein, and *Speleketor*, new genus. The two latter genera are distinctive because of the wing venation and the very long segments in the antennal flagellum. *Prionoglaris* contains one species occurring in European caves, while a single new species of *Speleketor* lives in Arizona caves. The absence of a lacinia in adults of *Prionoglaris*, in addition to other peculiarities, makes the genus of unusual interest, and special attention is given to the mouth parts of *Prionoglaris* and *Speleketor*. *Scoliopsyllopsis* Enderlein is a synonym of *Prionoglaris*.

*Psyllipsocus* is best known on account of its genotype, *ramburii* Selys, which is dimorphic and often found in houses in Europe and America. *Paremptheria* Enderlein is synonymized with *Psyllipsocus*. Attention is called to a paper by Weber (1906), overlooked by most writers, in which one new generic and two new specific names were proposed, apparently unintentionally. Three species of *Psyllipsocus* are recorded from America, two being described as new, and a key for their separation is given. Four additional species and one variety have been described from the Old World, and notes on each of them are given.

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SOME AMERICAN GEOMETRID MOTHS OF THE SUBFAMILY ENNOMINAE HERETOFORE ASSOCIATED WITH OR CLOSELY RELATED TO ELOPIA TREITSCHKE, by HAHN W. CAPPS. *Proc. U. S. Nat. Mus.* 93: 115-151, 10 pls. 1943.

THE TYPE SPECIES OF THE GENERA AND SUBGENERA OF BEES, by GRACE SANDHOUSE. *Proc. U. S. Nat. Mus.* 92: 519-619. 1942.

The above three items received recently explain themselves by title. They appear to be taxonomy of a revisional nature, a type of study very much needed in American insects. American bees particularly need work other than the description of more new species. The untimely death of Miss Sandhouse was a severe blow to the present progress of just such revisional work on American bees.

—C. H. K.

# HOW THE COCKROACH DEPOSITS ITS EGG-CASE; A STUDY IN INSECT BEHAVIOR

PHIL RAU,  
Kirkwood, Missouri

It is generally thought that cockroaches which move about for several days with egg-cases protruding from their bodies eventually drop them casually in any moist place. The following observations on the two species of domestic roach, *Periplaneta americana* and *Blatta orientalis*, show conclusively that they do not drop the egg-cases indiscriminately, but usually hide them with great care in crevices, or bury them in soft wood or workable material. Moreover, they almost always cover them precisely with bits of debris, which sometimes they even carry from a distance.<sup>1</sup> Only recently I have been so fortunate as to be able to observe, step by step, these marvelous activities, which are so unlike the stupid, primitive creatures that roaches are generally thought to be.

In the very long time that cockroaches have been on the earth (they are the oldest of living insects), they have acquired behavior patterns which may be classified as clearly instinctive. On the other hand, in their work of safeguarding the egg-case after it has been dropped from their bodies, they solve problems created by unique and unprecedented situations with bits of ingenuity or adaptability which, in all honesty, can hardly be called less than gleams of intelligence. One has only to read the amazing report by Haber (Ent. News, 31: 190-193, 1920) on the performances of a mother American cockroach in caring for her egg-case to concur with this view. In discussing his observations I recently remarked, "One needs only to read the account of Haber to feel that if any insect behavior at all may be called intelligent, this is an example of it." It was largely to verify for myself if these broad remarks were justified that I spent many hours on several nights, closely observing the oviposition of cockroaches. A detailed account of the behavior of one typical mother of each of these two species is here given.

Cockroaches sleep by day and conduct all their activities, including oviposition, under cover of darkness. They are sensitive to light, and the observer bent on prying into their private lives soon learns that they will leave any task to scuttle to cover when the light is turned on. I soon found, however, that they can be conditioned to the rays of a flash-light if the light is dimmed by covering the lens with a thin cloth.<sup>2</sup>

With flash-light in one hand and a large reading-glass in the other, both carefully focused on an insect through the side of the glass box in

<sup>1</sup>The Life History of the American Cockroach, Ent. News 51: 121-124, 151-155, 186-189, 222-227, 273-278, 1940; and The Biology of the Roach, *Blatta orientalis*, Trans. Acad. Sci. St. Louis, 25: 57-79, 1924.

<sup>2</sup>Auditory Perception in Insects with Special Reference to the Cockroach, Quart. Review Biology 15: 121-155, 1940.

which they lived, I was able not only to discern every movement of the insect, but also saw them all magnified to twice their natural size.

### THE AMERICAN COCKROACH

With flash-light and magnifying glass, I observed a mother *P. americana* with egg-case protruding from her body (4 A. M. on May 29, room temperature 69 degrees F.) hollow out with her jaws a cavity in the side of an irregular piece of rotted elm wood that lay on the floor of the glass cage. She clung to the side of the wood, head diagonally downward, enlarging a shallow, round cavity a quarter of an inch in diameter. She continued for some time biting away portions of the wood, often stretching her neck to reach a remote part of it.

A tiny pile of sawdust lay on the floor just beneath the hole, and as she worked she brushed together from time to time the new accumulation of chips and dust in the hole, and, with mouth and legs, threw them to the floor. The jobs of excavating the hole and disposing of the litter were slowly and carefully done, although somewhat awkwardly. Often the mother would leave her work, descend to the floor and brush the scattered bits of wood-dust into the pile. She did not use her legs for sweeping, as most insects in a similar situation would have done, but made a brush of her head and mouth-parts, and quickly swept the dust under her body, bit by bit, while slowly she moved backwards.

After digging in this way for half an hour, she rested on top of the wood for several minutes. Finally she walked to the edge of the deepened cavity, stretched her head into it and kept it there for two or three minutes; when she removed it there was a small pool of glistening liquid at the bottom. This material had come from her mouth, but was not the usual thin, black saliva, but appeared to be a more glutinous substance. After she had spat this on the bottom of the hole, I expected oviposition quickly to follow, and in this I was not mistaken. After idling about for a little while, she grasped the wood with her legs, placed her abdomen directly over the cavity and curled it under until the tip with its egg-case was partly in the hole; then with a few convulsive movements of the abdomen she dropped the egg-case into the mass of adhesive material.

At this point let me digress, and add for comparison the behavior of another mother of the same species a few nights later. This one was spitting the secretion, drop by drop, for a period of twelve minutes, into a cavity which she had already made; however, she rolled each drop about in her jaws for several seconds before she permitted it to fall. This manipulation of the saliva made me suspect that she may have been mixing it with some adhesive secretion from glands in the mouth. Her method of dropping the egg-case into the pool differed slightly from that of the first roach. In this case the cavity was on the top of the piece of wood and not in its side, so she did not need to resort to acrobatic contortions to get her abdomen into the cavity. She merely took her position squarely over the hole, curled her back until it formed a circle, and then with several forceful movements of contraction and expansion, lasting perhaps half a minute, she forced the egg-case from her body into the pit.

. Now let us return to the first mother, who had gotten so far as to drop her egg-case into the pool and was resting on top of the wood. The piece of wood was small and of light weight, and sometimes when she was digging into it, it rocked back and forth with her energetic movements. Often too, in combats with trespassing sister roaches (these conflicts were nothing more than leg-biting and leg-pulling), the piece of wood would sway perilously. But she was so engrossed in her work that she seemed not at all conscious of the motion—and hardly aware too of the brighter light which now played upon her, for I found that by now I could safely remove the cloth covering from the lens. Suddenly her attention was turned to a comrade who was biting out and carrying away bits of wood from her domain. In the tug-of-war which followed, both cockroaches tumbled to the floor and the piece of wood rolled over and landed with the cavity flat against the floor—I thought forever barring the mother from her egg-case.

After regaining her poise and cleaning her antennae for a few seconds, she went in search of her lost property, finally recognizing it among similar pieces of wood near which it had fallen. She then spent several minutes probing over it with palpi and jaws in search of the opening. Undaunted by failure, she climbed to the top again, and with seeming deliberation she tugged at it this way and that for several minutes, often grotesquely pulling it while still on top of it, and sometimes falling to the floor in the struggle. After several such falls she finally ceased tugging at it and, to my astonishment, climbed on top and resorted to the process of rocking it to and fro; this she continued for several minutes, when suddenly it yielded and rolled over, sending her again headlong to the floor. Nevertheless, she had accomplished what she had attempted, for now the cavity was exposed and the egg-case within it was still in its moorings. The mother easily located the pocket, poked her head into it, and withdrew bringing out the egg-case securely in her jaws.

She set it down carefully near the edge of the hole with the serrated edge uppermost, picked it up again after a few seconds, held it again with the important serrated edge topmost and finally, by stretching her neck far into the cavity, imbedded it carefully, serrated side up, into the pool of glutinous substance. The attention given to the position of the egg-case is evidently due to the fact that the young on hatching emerge only through the serrated edge of the capsule, and to fasten it with that edge downward would spell disaster for the emerging young. The mother had no control over the landing of the egg-case when it fell from her body, but she left no stone unturned until she was sure it was in the right position.

Her work was still far from finished. She now spent several minutes with her head in the cavity, and when she withdrew it the egg-case was completely covered with a layer of glistening moisture. Her next move was to cover it with saw-dust, and this she did by gathering mouthfuls of it from the floor, carrying it to the hole and carefully gluing each load in place until the capsule was entirely covered. She did not throw it in casually, but strained her neck to place each load where she wanted it.

While she was thus occupied, conflicts with other roaches that wandered into her territory again "upset the apple-cart" and the piece of wood again rolled over, but this time without hiding the opening. The hole was now on the opposite side from where it had been, but the egg-case was still accessible. She seemed much perturbed, and attempted to place the piece of wood in its old position by climbing upon it and performing a series of indescribable acrobatic feats; thus she rocked it back and forth for many seconds until finally it regained approximately its original position. This apparently satisfied her, and she resumed the gathering of sawdust which now she merely dumped on top of the egg-case. This process of filling the hole with loose material was in sharp contrast to the precise work of gluing mouthfuls of sawdust all over it, as explained above.

It was five o'clock when I went to bed, leaving her to continue her monotonous work (an hour had elapsed since I had begun watching her). She must have worked on for another hour, for when I returned at sunrise I found the cavity filled to its brim, and when I probed into it with a straw, I found it tightly packed.

Now that we have seen her use the sawdust in the later stages of egg-case concealment, we can better appreciate her persistence in conserving it in a neat pile during the earlier operations. This detail of behavior is not standard, however, for I have seen other roaches of both species, instead of saving the sawdust and brushing it into a pile, go to nearby pieces of wood, clay or cotton wadding and bite away bits to use as covering material, or even plaster the capsule beyond recognition with pellets of roach excrement dissolved in saliva.

Since this roach had been at work for probably a half-hour before I began to observe her, she must have spent at least two hours altogether on the job of attending to the safety of her egg-case.

### THE ORIENTAL COCKROACH

It was at 8:30 P. M. on June 26 that I saw a mother *B. orientalis* at work in a shallow tin jelly-glass lid filled with white sand. This lid and sand had been on the floor of the glass box for several months, and from it from time to time I had removed egg-cases that had been glued by the ovipositing females to the bottom and the inner edge of the rim.

This insect, with egg-case protruding from her ovipositor, was in the center of the dish busily sweeping away the sand with her legs, apparently trying to reach the bottom. The legs moved rapidly, and the stream of sand was brushed back in an irregular jet. She used the four front legs in this procedure, but used only two of them at a time, first the two on one side of her body, and then the two on the other. The legs never worked in pairs (*i. e.*, one on each side), and even though two of them moved at one time, they seldom moved in unison. The result was to send a clumsy stream of sand into the air on one side or the other of her body. In this behavior she differed somewhat from the American roach described above, who for a similar job used the palpi and jaws instead of the legs, and thereby sent the dust in a stream under her body to its goal.

After spending eighteen minutes brushing away the sand, she

uncovered the shiny bottom of the tin. Much of this time might have been saved, had she not often strayed from her work to make exploratory excavations in other parts of the tin. When the bottom came into view, she abruptly stopped work, and without loss of time lifted her body high on her legs over the clearing, humped her back into a ring, and then with abdominal contortions which lasted fully a half-minute, forced the egg-case from her body and into the center of the cleared spot. The deliberation with which each move was done indicated that the egg-case was not dropped indiscriminately, but the preparation of the site and the deposition of the ootheca were carefully made.

After dropping the egg-case, she relaxed from her extreme pose and rested for several minutes. Then, turning around suddenly, she placed her mouth to the capsule and spread a thick layer of glutinous secretion all over it; this required about three minutes. She then picked up the egg-case with her jaws, righted its position on the tin so that the serrated edge was uppermost and spent several minutes apparently pressing its seams together by running her jaws back and forth over it, pressing it tightly here and there, all the while spitting saliva over its edge as if knitting and cementing it together, all at one time. Whether or not this extra precaution was necessary I do not know; I had had the impression that the two edges of the seam naturally dovetailed tightly together, and that the seam would split automatically when the expanding nymphs were ready to emerge.

The cockroach spent the next forty-five minutes covering the sticky substance with grains of sand; when she ceased, every portion of the ootheca was completely covered and hidden from view. During this entire period of forty-five minutes, she had never once changed her position; her mouth was always near to the egg-case, and when she needed grains of sand she merely stretched her long neck to one side or the other to obtain them. Moreover, she did not take the first grains of sand that came to hand, for with my magnifying glass I could distinctly see her selecting some and rejecting others. With the aid of her sensitive palpi she discarded the small grains and retained the large ones, holding several of them in her mouth while at the same time selecting others, all the while actively rolling them in her mouth where they became saturated with the fluid. She then glued small mouthful after mouthful carefully in position on the capsule.

At the end of this forty-five minutes of arduous work, apparently she felt that the egg-case was completely disguised, for now she changed her position on the sand and also changed her method of work. By quick movements of the four front legs, in the manner already described for her excavating maneuvers, she directed an avalanche of sand grains in the direction of the egg-case, continuing until after a few minutes it was completely covered. The task was finished, but her frenzied momentum would not permit her to stop; she continued to sweep the sand this way and that for at least a half-hour more, in other parts of the dish where, in my opinion, it could not do the remotest bit of good to the egg-case, unless possibly she was obliterating her foot-prints or odor trails. When at last she stopped to rest, her black body was most amusingly peppered with grains of white sand. Even then she seemed loathe to leave the scene of her work, and spent another hour quietly in the center of the dish.

## ANALYSIS OF THE BEHAVIOR PATTERN

Contemplating this picture of cockroach behavior, one is soon aware of certain traits which are (a) outstandingly instinctive, (innate powers or inborn capacities, if one should dislike the term instinct), and other bits of behavior (b) which connote intelligence (and by intelligence I mean the capacity to learn and the ability to adapt learned or instinctive behavior to new situations, as well as the ability to understand situations and to form, as Turner has suggested for ants, "practical judgments"). Then in the border-lands we may ponder over behavior patterns (c) which combine both instinct and intelligence, the one not appearing without the other.

In reviewing examples from each of the three categories, I may cite as instinctive (a), the mating behavior; gregariousness; the shunning of light and seeking of darkness. As exceptional activities extending into the field of intelligence (b), the conserving of sawdust for use at a future time; the persistent and effectual work in turning over the piece of wood so she could reach the hidden egg-case; recapturing the egg-case when it bounded to the other side of the cage, and replacing it in the depression in the cardboard (Haber). As examples of behavior which seem to be a combination of both instinct and intelligence, I may cite (c), retrieving the egg-case after it had been dropped into the viscid liquid and resetting it with the openings topmost; covering the capsule with layers of rust, which must have been difficult to obtain, to render it inconspicuous in its position in the rusty tin lid, when plenty of material of other color was convenient at hand (*op. cit.*); selecting the large grains of sand, and rejecting the small ones to roll in the mouth and glue onto the capsule.

But all of this was anticipated by Dr. Wm. M. Wheeler when he says, in speaking of insects other than cockroaches, "Most of the activities can readily be interpreted as chain-reflexes, or 'instincts' in the usual biological sense of the term. They are relatively fixed or stereotyped and undoubtedly hereditary and therefore represent the most ancient and most solidified complex of the behavioristic cycle. But there stand out from this complex many activities which are much less mechanized and of such a nature as to demonstrate that the wasps (insects) possess emotions and associative memory, that they exercise discrimination and choice, that they learn by experience, and form habits in the restricted sense of the term and that they can modify their behavior adaptively in response to unusual stimuli on the basis of previous experience and therefore behave, to a limited extent, like intelligent beings."<sup>3</sup>

The concise epigram by Remy de Gourmont is apt in this connection: "One would attribute to the instinct, the series of acts that conserve the present state of a species; to the intelligence, that which tends to modify the state."

<sup>3</sup>Introduction to "Wasp Studies Afeld," pp. 5-6, 1918.

# **DIMORPHISM IN THE FEMALE HONEYBEE (*APIS MELLIFERA* L.): DEVELOPMENT OF THE METATHORACIC TIBIA<sup>1</sup>**

MAXWELL E. POWER,  
Osborn Zoological Laboratory,  
Yale University,

and

R. M. MELAMPY,  
Department of Zoology,  
Louisiana State University.

The dimorphism existing between the two female castes of the honeybee (*Apis mellifera* L.) represents a conspicuous example of the effect of environment upon insect development. The mechanism by which female larvae are differentiated into queens and workers is assumed to be determined by the food and care received during the larval period, because it is generally accepted that all female larvae have similar genetic constitutions and that such ecological factors as temperature and relative humidity are similar during the development of both castes.

Larvae receive royal jelly, a glandular secretion of the nurse bees, for 2 days after hatching, and then the diet of the workers is changed, but the queens continue to receive the secretion. Chemical analyses have demonstrated that royal jelly contains many of the known nutritive substances required by animals for growth, maintenance, and reproduction—proteins, carbohydrates, fats, minerals, vitamins, and water. Melampy and Jones (1939) have shown that royal jelly from queen cells containing larvae 3 to 4 days old has the following approximate chemical composition: moisture 66 per cent and dry matter 34 per cent, the latter consisting of protein 36, fat 16, total reducing substances (calculated as glucose) 37, ash 2.4, and undetermined material 8.6 per cent. Royal-jelly protein has a digestion coefficient of 81 per cent and a biological value of 75 per cent, indicating that it is of considerable value in the building of body tissue. Royal jelly is a good source of vitamin B<sub>1</sub> but contains no demonstrable amount of vitamins A, C, or E. The fact that it contains little, if any, of these vitamins indicates either that the queen bee does not require these accessory factors or that the amounts present are too small to be detected.

On the assumption that pollen and nectar are the only foods provided the worker larvae after the change in diet, it may be suggested that this diet has either specific nutritional deficiencies or it cannot be sufficiently utilized by the larvae to meet genetic requirements for growth. Of course, pollen and nectar are considered the principal foods of the adult worker caste, and they apparently meet the require-

<sup>1</sup>A contribution from the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, in cooperation with Louisiana State University.



ments for adult maintenance as well as for the secretion of royal jelly and wax, but it is well known that the nutritional needs of adult animals are quite different from those of the rapidly developing young of the same species. Chemical studies have been made on worker food by von Planta (1888) and Koehler (1922). However, the biological value of the worker diet should be determined in order that comparisons may be made with the diet of the queen.

Von Rhein (1933) has reported that presumptive queen larvae are fed a special secretion, in addition to royal jelly, which determines their future course of development, but this observation has never been confirmed. Heyl (1939) and Townsend and Lucas (1940) suggest that royal jelly contains a gonad-stimulating substance which may be associated with caste differentiation. However, Melampy and Stanley (1940) were unable to find a substance in royal jelly which causes follicle stimulation in the white rat. After reviewing some of the literature, Haydak (1939 and 1940) postulated that the female dimorphism is the result of a differential secretion of one or more hormones by the developing larvae of the two castes, but he did not consider the factors that initiate this difference.

This paper reports a study of the dimorphic development of the tibia of the metathoracic leg of the two female castes in the honeybee. In the worker caste the outer surface of the tibia of the metathoracic leg is smooth and concave and has no setae, but is fringed with long setae which curve outward and slightly over the naked surface, the arrangement being commonly known as the corbicula, or pollen basket (fig. 3). The corresponding surface of the tibia of the metathoracic leg of the queen is characterized by the absence of such a modification (fig. 1). Since honeybees are specialized feeders, this adaptation is important to the nutritional economy of the colony, as it is used by the workers to transport pollen to the colony. Casteel (1912) has made an extensive study of the pollen-gathering behavior of the worker honeybee, as well as observations upon the morphological structures involved.

The purpose of this investigation is twofold: (1) By studying the setae on the tibia of the metathoracic leg, to secure information on the sequence of events in the development of a body structure that may serve as a basis for experimental inquiry into the time of determination of a dimorphic caste character in female honeybees; (2) to obtain more detailed information as to the developmental morphology of this structure for pollen gathering, because of the importance of honeybees in the pollination of plants useful to man.

## MATERIALS AND METHODS

The workers used in this study were taken from several colonies of Italian bees. Larvae and pupae of known age were obtained by permitting the queen to oviposit for 24-hour intervals on dated brood frames. The immature queens were produced by transferring newly hatched female larvae to queen cells and allowing them to develop in queenless colonies.

Observations were made upon three general sorts of material—living metathoracic legs, permanent mounts *in toto*, and serial sections. Pre-

liminary studies were made upon living legs of all stages. The appendages are easily removed, even from larvae, by placing the insect, with its ventral side up, in a physiological salt solution and making a slit in the larval cuticula over the pair of legs. Interval pressure is sufficient to cause the limbs to slip out through this incision, where they may be easily clipped off. Alcoholic Bouin's solution was used as a fixative. The whole mounts were stained either with Conklin's haemotoxylin or with borax carmine followed by bleu de Lyon. The former stain acted more quickly and gave more uniform results, but it had the disadvantage of giving greater opacity. The latter stain often made brilliant preparations, staining the hypodermis red and the setae blue, but on the whole the reaction was less uniform. To stain entire legs after pupation, it was necessary to peel off the pupal cuticula, which is impermeable to most stains. The serial sections were cut at 15 or 20 microns and were stained with Delafield's haematoxylin and eosin.

## RESULTS

Since both queens and workers develop from similar eggs and since both castes receive similar food and care through the second day of larval life, the origin and early development of the legs are alike in both castes. Leg rudiments make their appearance during early embryonic development. In embryos 44 to 46 hours old the anlagen of the legs are visible, and by 60 to 62 hours they are clearly seen as three pairs of evaginations from the ventral body wall of the thoracic segments (Nelson, 1915). At about the time of hatching the body wall folds over them and encloses them in a peripodial pouch. In later development the distal ends of the legs extend from the pouches and the tips of each pair grow toward the median ventral line, where they touch (fig. 4). The legs do not invaginate during development, and their surface is therefore never entirely inverted, as is typical for the imaginal discs of the Diptera (Weismann, 1864). They lie right side out, folded beneath the cuticle, and extend from the pouches which enclose their proximal ends.

In the larva the hypodermis of the tibia is folded into large, loose undulations (the primary folds) caused by the crowding of the legs into a confined space. The day before pupation the primary folds are replaced by tightly folded secondary pleats, the axes of which lie at right angles to the long axis of the tibia (fig. 12). From sections (fig. 9) it may be seen that the basement membrane does not parallel the contours of the surface, but that alternating rows of tall and shorter cells allow the surface to be raised up into more distinct contours than that of the underlying membrane. At pupation the secondary folds are smoothed away by the extension of the limbs, just as the wrinkles in a balloon are obliterated by its inflation. The hypodermal pleating is obviously a mechanism prepared in advance which permits the sudden lengthening of the leg at the time of pupation.

Earlier than the day preceding the fifth larval molt, pupal cuticle is not clearly present on the distal ends of the hypodermal cells, and whole legs stain easily. Late in the day of pupation stains will not penetrate the surface; sections through legs at this time show the presence of a thin cuticle, thereby giving physical as well as histological

evidence that the cuticle of the pupa is secreted during the pupal period. The surface of the pupal cuticle is marked off into polygonal areas, each unit corresponding to the end of one cell. Within each of these sculptured spaces is a hooklike extension, which is a characteristic feature of the pupal cuticle.

A few days before pupation a large and a small spur are formed at the distal end of the tibia of the third leg, on the anterior, inner side. They are simple evaginations of the hypodermis, and the pupal cuticula is molded over their surface. Figure 12, which was drawn from the outer surface, shows only the larger of the two spurs.

The day following pupation the hypodermis retracts from the pupal cuticle and forms a subcuticular space which is filled with a liquid. The spurs are completely reduced, but their original shape is detectable in the overlying cuticle, where they serve as convenient points to be grasped with tweezers when the pupal cuticle is peeled away in preparation for staining. It would appear that the adult cuticle is in the process of formation during the second day following pupation, for after the first day the surface of the leg again becomes impermeable to ordinary stains.

Two days before pupation the nuclei of the hypodermis are nearly spherical and are of approximately the same size. They are crowded so close together that they almost fill the entire thickness of the epithelium from the basement membrane to the surface (fig. 6). The cell walls which

#### EXPLANATION OF PLATE I

All figures, except fig. 4, drawn with aid of camera lucida.

Fig. 1. Lateral view of right leg of adult queen honeybee.  $\times 13$ . 2. Section through tibia of worker pupa (9-10 days) in which pupal cuticula has been removed. Outer, or corbicular, surface, which is on right side, is free from setal cells.  $\times 64$ . 3. Lateral view of left leg of adult worker. Note single large seta arising from corbicular surface.  $\times 13$ . 4. Diagram of ventral half of a transverse section through larva showing relation of imaginal legs to body wall. 5. Transverse section through tibia of queen pupa (7-8 days) in which pupal cuticula has been removed. Lateral hypodermis, which is placed on right side, contains setal cells.  $\times 64$ .

#### Abbreviations used on figures

AU.....	Auricle	NV.....	Nerve
AT HYP C....	Attenuated hypodermal cell	OEN.....	Oenocyte
BC.....	Blood cell	OES.....	Oesophagus
B M.....	Basement membrane	PC.....	Pecten
CB.....	Corbicula	PD MB.....	Peripodial membrane
CLA.....	Claw	PUP CUT....	Pupal cuticula
F.....	Femur	S BR C.....	Smaller bristle cell
F C.....	Fat cell	SC FL.....	Secondary fold
HM SN.....	Hemolymph sinus	SLK GL.....	Silk gland
HYP C.....	Hypodermal cell	S M.....	Sinus membrane
HYP CB.....	Hypodermis of corbicula	SP.....	Spur
HYP N.....	Hypodermal nucleus	1 TAR.....	Basitarsus or planta
HYP O.....	Hypodermis of outer side of tibia	5 TAR.....	Fifth tarsal segment
IM LEG.....	Imaginal leg	TB.....	Tibia
INT S.....	Intercellular space	TMG.....	Tormogen
L BR C.....	Large bristle cell	TR.....	Trachea
M B.....	Muscle bundle	TRG.....	Trichogen
		V NV CD....	Ventral nerve cord

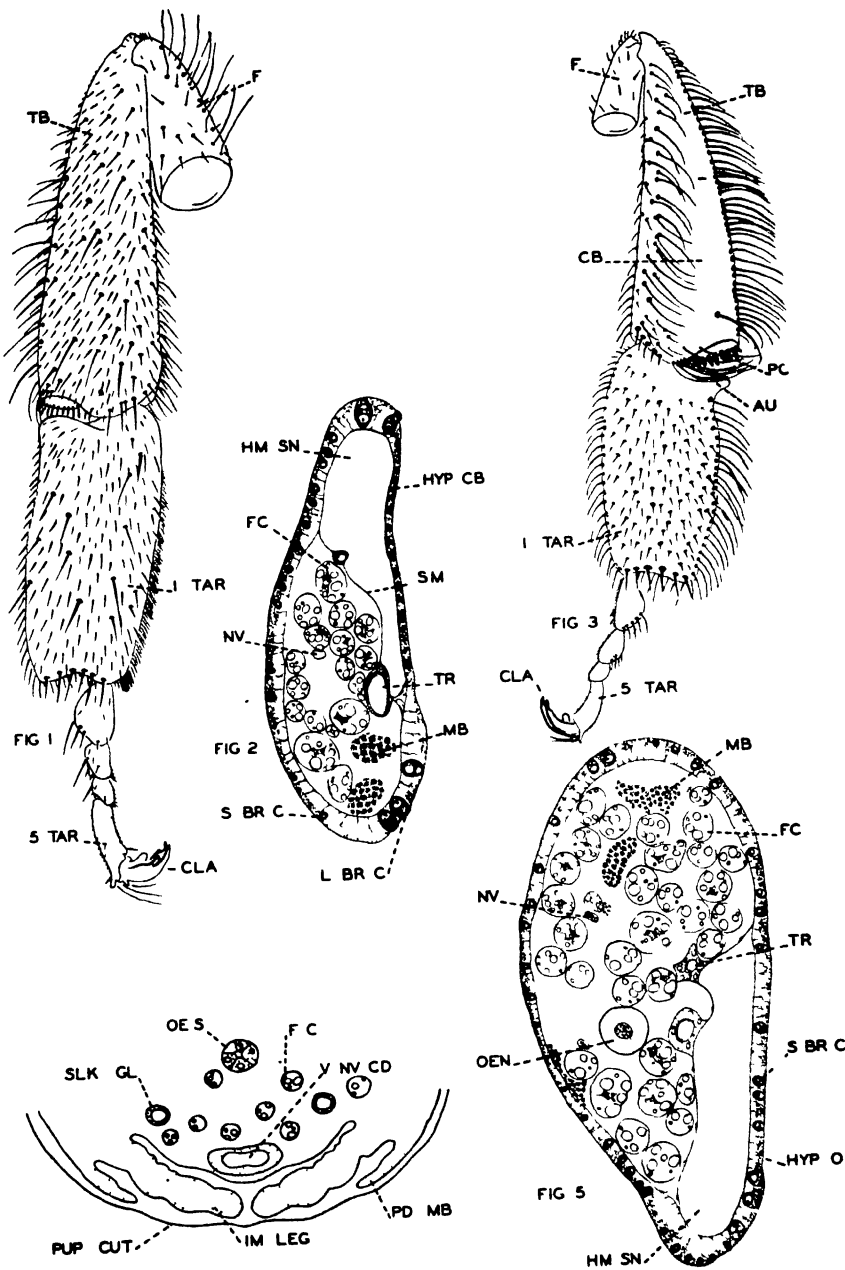


FIG. 4

lie between the nuclei are not visible at this time; therefore, it is impossible to know whether the hypodermis is histologically a true stratified epithelium or a pseudostratified type; however, it is probable that in early stages the latter description may be the true one. A change in the position of the nuclei occurs in the hypodermis of the legs on the second day before pupation. Late in this day an increase in the area of the hypodermis permits the cells to form a single columnar layer, and the nuclei are near the basal ends of the cells. The cytoplasm surrounding them is dense and stains darkly, whereas in the distal ends the cytoplasm is clear (fig. 7). Later in the same day the nuclei are found in the center of the cells, and shortly before pupation they and the darkly staining cytoplasm are next to the distal wall of the cells, whereas the cytoplasm near the basement membrane is then clear. The pupal cuticle is formed during the period of migration of the nuclei.

From the time of pupation the hypodermis of the leg is a tall, simple, columnar epithelium; however, it has a distinctive appearance because the cells are long and stringlike. The cytoplasm surrounding the nucleus is dense and is applied to the external surface of the tibia, the distal ends of the cells being nearly contiguous (fig. 11). The remainder of the cell is attenuated into a thin, lumpy thread, which reaches to the basement membrane (fig. 10). Between the stringlike proximal ends there is considerable intercellular space that is filled with a fluid, possibly hemolymph, which shows a slight reticulation upon fixation. The strings are longest at the edges of the corbicular surface of the worker tibia.

The important difference in morphology between the queen tibia and that of the worker is the occurrence and distribution of the setae; the typical pattern is shown in figures 1, 2, 3, and 5. In the honeybee, as is typical of other insects (Snodgrass, 1935), each large seta is characterized by two special cells at its base, from which it is formed. The cell that gives rise to the seta is the larger and lies deeper in the hypodermis; it is called the trichogenous cell, or trichogen. The second, smaller cell lies above the larger; it surrounds the base of the seta and is called the socket cell, or tormogen (fig. 10).

Two days before pupation the nuclei of the tibial hypodermis have a uniform appearance. However, during this second day before pupation the nuclei assemble in the half of the hypodermis next to the basement membrane, and approximately 24 hours later several mitotic cells in

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#### EXPLANATION OF PLATE II

All figures drawn with aid of camera lucida. For key to abbreviations used, see Explanation of Plate I

Fig. 6. Section of tibial hypodermis of queen larva 5 days old, showing nuclei throughout entire thickness.  $\times 715$ . 7. Section of tibial hypodermis of worker larva, in middle of its seventh day, showing nuclei close to basement membrane.  $\times 715$ . 8. Section of tibial hypodermis of worker larva in later part of its seventh day, showing mitoses.  $\times 715$ . 9. Transverse section through two secondary folds in hypodermis of worker larva 8 days old.  $\times 715$ . 10. Section through large pair of setal cells and adjacent hypodermal cells from tibia of worker pupa (9-10 days).  $\times 715$ . 11. Surface view of tibial hypodermis of young worker pupa (8-9 days), drawn from whole mount.  $\times 375$ . 12. Lateral view of tibia of worker 8 days old, a few hours before pupation, with hypodermis bearing secondary folds.  $\times 50$ .

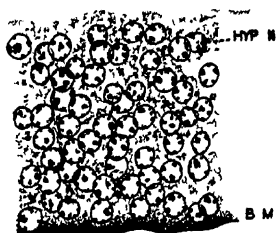


FIG. 6

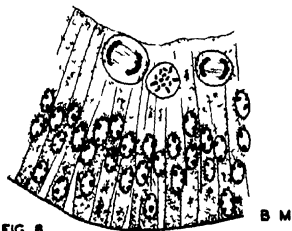


FIG. 8

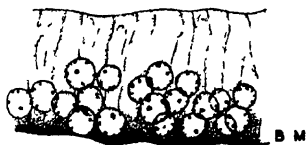


FIG. 7

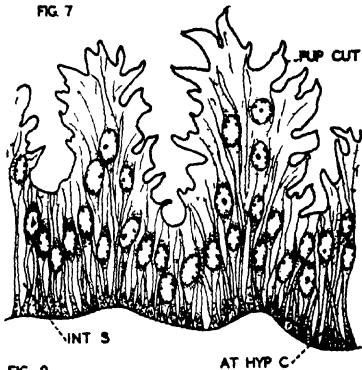


FIG. 9

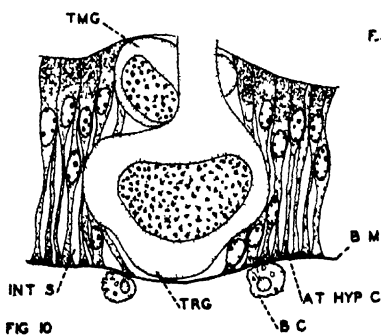


FIG. 10

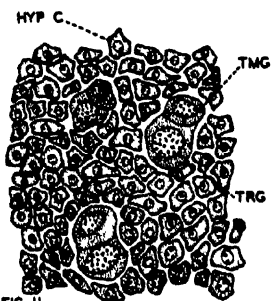


FIG. 11

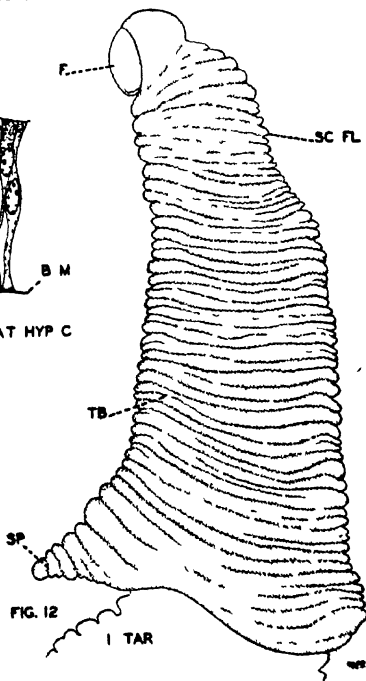


FIG. 12

various stages of mitosis are found in the clearer outer cytoplasmic portion (fig. 8). It is probable that the trichogen and tormogen of a setal pair are the result of the division of one of these hypodermal cells. The mitotic spindle is usually oriented in a plane parallel to the surface, but after telophase the two daughter cells shift their position so that one, the tormogen, comes to lie above the other, the trichogen. A line drawn through both cells would be nearly perpendicular to the surface. The trichogen becomes larger than the tormogen, and from the former a process of cytoplasm extends through the tormogen and beyond the hypodermal surface. This process becomes a seta, and cuticle is deposited upon its surface during later stages of development. The pairs of setal cells of both queen and worker fall into two distinct size categories. The average diameters of the trichogens and their nuclei of the larger pairs are 264 microns and 198 microns, respectively, whereas the trichogenous cells in the smaller pairs have average cell diameters of 132 microns and nuclear diameters of 99 microns. The larger pairs are thus twice as large as the smaller. The size of the setae produced varies roughly with the size of the cells. The cytoplasm of the setal cells is dense and homogenous, and the nuclei are more evenly granular than those of the surrounding hypodermal cells (fig. 10).

When the two castes are considered separately, it is evident that the development of the hypodermis and its related structures on the tibia of both occurs during a 4-day period. In the queen this period occurs from about the fifth through the eighth day, and in the worker from the seventh through the tenth. Prior to this there is no evidence of seta formation and the tibiae are morphologically similar in both castes. Pupation occurs within this period. It would appear that pupation is the important factor in each case, for when the time of pupation is changed in either direction, the whole period is moved forward or backward accordingly. Because of the nature of the manipulation necessary to produce queens experimentally, the time at which they pupate is more variable than it is in the worker. In this work the pupation of the queen was observed to occur late in the sixth day, and at other times in the seventh. The important fact, however, is the event of pupation, for this process is the result not of a chronological age, but rather of a definite physiological threshold and morphological attainment.

The chief differences between the two castes as regards the differentiation of the tibia may be enumerated as follows:

*Queen*.—On the day before pupation (6th) the hypodermal nuclei undergo migration, mitotic figures lie next to the cuticula on both the outer and inner surfaces of the tibia, the pupal cuticle begins to be formed, and the secondary folds are produced. On the day of pupation (7th) the adult size of the leg and the definitive number of setal cells is reached. On the day after pupation (8th) the hypodermis retracts from the pupal cuticle, the setal processes grow from the trichogenous cells, and the imaginal cuticle begins to be produced.

*Worker*.—One day before pupation (7th) the hypodermal nuclei migrate, and mitotic cells are present at the surface except on the outer side of the tibia, which will be the corbicula. On the day of pupation

(8th) but before it occurs, the definitive number of setal cells is attained and the secondary folds are produced. The day after pupation (9th) the hypodermis retracts from the pupal cuticle and the processes that will form the setae extend from the trichogens. On the second day after pupation (10th) the setae attain their full length and the cuticle of the adult begins to be secreted.

The presence or absence of setae from the outer surface of the metathoracic tibia is the basis of the dimorphism of this segment. The first evidence of setal formation is the occurrence of the pairs of larger cells in the hypodermis. In the queen these cells are found on both the outer and inner surfaces of the tibia by the time of pupation (6th or 7th day of larval life), and in the worker they are found on the inner side of the tibia by pupation (8th day); but at no time during development are they found in the outer, corbicular surface. The establishment of the characteristic setal pattern is manifest a day earlier in the queen than in the worker, but in both it bears the same time relation to pupation.

Before this investigation was started it was thought that in early stages setae might be found developing on the outer as well as on the inner surface of the worker tibia, and that in later differentiation the primordia on the corbicular surface would regress so that no setae would be produced by them. This was not found to be the case, however, for from the time setal cells could first be distinguished from other hypodermal cells, the future corbicular surface appeared free from them.

## DISCUSSION

In this study of the development of the setae present on the metathoracic tibia in the queen and the worker honeybee, it was observed that the events are the same, their order of occurrence is alike, and even the time sequence is similar, the most conspicuous difference being that the events occur about 2 days earlier in the queen. These observations upon morphological structures in development are in close agreement with physiological data, which show that the worker caste is characterized by a retarded development. A biochemical study of the differentiation of the female honeybee has shown that queens and workers have approximately the same growth rate during early larval life, and that later the growth of the worker caste is retarded, as shown by the nitrogen, total lipid, total reducing substances, and calorific value (Melampy, Willis, and McGregor, 1940).

In addition to the nutrition of the larvae, which has been discussed, it might be suggested that differences in rate of development could be partly responsible for the dimorphism existing between the two female castes. Recently Goldschmidt (1938) reviewed an extensive literature which demonstrates that often the developmental cause of phenotypic variations can be assigned to differences in the rates at which growth processes occur. It might, then, be suggested that the dimorphism of the tibia could be a result of the two rates of development which the two castes are known to possess. Melampy and Willis (1939) have shown that the developing queen caste possesses a higher metabolic rate than does the worker. The oxygen consumption and the carbon dioxide production of the queen decrease during the period of bristle formation,



whereas during the comparable stage of the worker the metabolic rate remains relatively constant, but at all times lower than that of the queen. Although the cause of this difference in rate is not temperature, because the two castes develop under the same colony conditions, it would be of interest to know if, by increasing the rate through experimental raising of temperature, presumptive workers might be made to complete their development in a less workerlike condition than they would have normally. Von Rhein (1933) concluded from experiments with temperature that the rate of development had no effect on the attainment of dimorphism in the honeybee. Even if these results should be later disproved, it is to be remembered that in the colony the normally existing difference in metabolic rate between the two castes may be basically initiated by a nutritional deficiency.

The adult worker and the queen may be considered to be the two extreme expressions of a like, or at least a very similar, gene complex because they arise from similar eggs. During the first 48 hours after hatching the female larvae are capable of developing into either queens or workers. This undetermined condition is utilized in the commercial production of queens by transferring 1- or 2-day-old larvae from worker cells to queen cells, in which they are permitted to complete their development in queenless colonies. Zander and Becker (1925) claim that a critical period occurs between 78 and 90 hours. Before this period female larvae are equipotential with respect to their adult caste; after this period they can develop only into the worker caste. Queens reared from larvae transferred during the critical period develop into "intercastes." It seems evident that female honeybees follow a single course of development. In offspring from a homozygous queen the dimorphism would, indeed, represent a development of two distinct phenotypes from the same genotype.

The ontogeny of any animal comprises a series of restrictions in potency due to successive determinations of its parts to follow only certain lines of development. In the honeybee such a series of determinations includes the establishment of the primary axes of the egg, the limiting of parts of the blastoderm to form certain embryonic structures (12 to 24 hours, Schnetter, 1934 a and b), and the restriction of a part of the embryo to form the metathoracic legs of the imago (before 44 hours, Nelson, 1915). But the most important determining process with respect to the present study is the one imposed upon the imaginal leg rudiments, which limits the destiny of the tibia, deciding whether they will form the worker or the queen dimorphic character. The time when this determination becomes established is not yet known, but the data presented in this paper indicate that it must occur between the second day of larval life and the second day before pupation.

Even though 2 days before pupation the tibia of the two castes are so similar histologically that they are indistinguishable, it cannot be supposed that the event of determination has not already occurred by that time. For, as Woodger has pointed out, although "two entities are manifestly, i. e., observably, non-different, we cannot infer that they are not intrinsically non-different" (quoted from Needham, 1936, p. 75). Later transplantation experiments with the limb rudiments

should reveal more exactly the time of determination of this caste character. Even when this is accomplished, however, it will not follow that all the dimorphic traits are also determined at that time.

### SUMMARY

The developmental morphology of the metathoracic tibia, with respect to its dimorphic structure, in the two female castes of the honeybee (*Apis mellifera* L.) has been studied. The characteristic setal pattern for each caste is already established by the time the setal anlagen are first histologically evident. The events of hypodermal differentiation associated with setal development are coincident with pupation. In both castes the setae appear above the surface of the hypodermis the day after pupation. Possible mechanisms involved in caste production in the female honeybee are discussed.

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## A NEW SPECIES OF CHLORION FROM CUBA

(Hym. Sphecinae)

H. T. FERNALD,

Winter Park, Fla.

### **Chlorion (Isodontia) bruneri** n. sp.

Body golden pubescent on clypeus, frons about up to the eyes, on the cheeks, horizontal part of the neck, on top of the collar, prothoracic lobe, sides and back part of mesonotum, traces on the female scutellum, postscutellum, a large spot above base of hind coxa joining its mate on the other side, a band from below the fore wing down along the episternal suture, another from the hind coxa to near the base of the hind wing and extending backward above to the propodeal spiracle. Pilosity golden, dense, particularly long on frons, sides of the body and on the legs. Head, body and petiole black; abdomen rather dull ferruginous with scattered darker shades. Coxae, trochanters and more or less of the femora black, strongly pilose.

*Female*.—Head: Clypeus somewhat swollen medially its entire length, its lower margin ferruginous, rather broad, particularly laterally, reflexed and projecting to form a tooth on each side of a broad central notch. Ocelli prominent, forming a much flattened triangle. Scape, pedicel and part of the first filament segment ferruginous, remainder black. Mandibles 3-toothed, ferruginous to the bases of the teeth which are black; with numerous long golden hairs near their bases.

Thorax: Collar narrow, front to rear, rising sharply from the neck. Mesonotum with a median depressed line on its front half; its surface with numerous medium sized punctures and minutely aciculate. Scutellum the same. Postscutellum entirely covered with pubescence and pilosity. Propodeal dorsum finely punctured between very small, closely packed transverse ridges; its end concealed by pubescence, with a rather deep fovea; sides with punctures and ridges like the dorsum. Metapleuron with small punctures where not covered by pubescence. Mesopleuron practically all covered by the pubescence. Petiole black, as long as, or slightly longer than the hind coxa and trochanter together, with many long, slender, golden hairs on its front third.

Abdomen dark ferruginous with many scattered darker shades, its surface above made sericeous by closely lying, whitish, very short hairs; below with scattered punctures and long, ferruginous hairs, mostly near the lateral margins of the ventral plates; last plate with numerous punctures.

Wings very slightly fuliginous; veins dark yellowish; 2d. and 3d. cells of fore wing very wide laterally.

Legs ferruginous except black coxae, trochanters and dark shades

on the femora; these with many long, golden hairs; rest of the legs pale ferruginous, heavily sericeous in places; spines pale ferruginous; claws large, as long as the tarsal segments they join; their basal half or more ferruginous and the outer parts and teeth black.

*Male*.—Clypeus with a slightly thickened lower black border which projects somewhat downward toward its middle where there is a slight depression. All parts of the antennal filament black. First abdominal segment partly black or dark; last plate above truncate behind; entire upper surface minutely sericeous, or if hairs are absent, reticulate; with numerous longer hairs particularly toward the sides on the last four plates; last ventral plate broadly rounded, broadly, slightly emarginate medially; with lateral clusters of rather long hairs on all the plates and rather dense bands of shorter ones across the last four plates. Femora black almost to their tips; claws all black; coxae, trochanters and femora heavily pilose, the femora and tibiae golden sericeous at certain angles; spines darker than the legs; last tarsal segment black or very dark. Otherwise as in the female.

*Holotype*: One female marked only "Cuba." *Allotype*: one male marked "Viñales 4-6-9-22 col. S. C. B. y J. A." Taken at Viñales, Cuba, April 6-9, 1922, by S. C. Bruner and J. Acuña. These types will be deposited in the U. S. National Museum. This species is named in honor of the collector of the allotype, Mr. S. C. Bruner, of the Estacion Agronomica, Santiago de las Vegas, Havana, Cuba.

This species resembles members of the subgenus *Ammobia* in its general stoutness of body, abundance of pilosity and pubescence, and in the presence of a part of a stigmatal groove, though some other species of *Isodontia* also have traces of this. But the absence of a tarsal comb in the female, the much greater width than height of the second cubital cell and the presence of short, three-toothed mandibles seem to place it as certainly an *Isodontia* rather than an *Ammobia*. It may be considered as the *Isodontia* nearest to *Ammobia* just as *Ammobia lucae* is the *Ammobia* nearest to *Isodontia*. These facts seem to indicate that the two subgenera have only rather recently been developed from a common ancestor and that some of the species have not as yet diverged strongly.

AMERICAN BUTTERFLIES AND MOTHS, by CECILE HULSE MATSCHAT, illustrated by Rudolph Freund. 70 pages 9 x 11¼ inches. 1942. Published by RANDOM HOUSE, New York. Price \$1.00.

This book is intended primarily to introduce these insects to nature lovers. It contains a general discussion of the structure, habits, and methods of collecting butterflies and moths, and presents a brief account of 73 common species. Each account consists of common and scientific name (with a pronunciation of the latter), a very brief description of the adult and caterpillar, and comments on the species. The book is excellently illustrated, with 14 full-page color plates and many sketches in black and white (though the only references to the illustrations are in the index).

This is a very attractive book, and one which should serve its purpose in arousing the interest of non-entomologists in this group of insects. Unfortunately, it appears to have been poorly edited, as we noticed some misspelled words, and a few of the illustrations are incorrectly labeled.—D. J. B.

## NOTE ON THE MALE GENITALIA OF CERTAIN ISODONTIA. (Hym.: Sphecidae)

RICHARD DOW,  
Reading, Mass.

Several years ago Mr. S. C. Bruner loaned to me for study a male wasp which Dr. H. T. Fernald has just described in the preceding paper, and designated as the allotype of *Chlorion (Isodontia) bruneri*. Though the specimen superficially resembled *costipennis* (Spinola), its three-toothed mandibles indicated that it might be an undescribed form of the group including *harrisi*, *elegans*, and *auripes*. The specimen was forwarded to Dr. Fernald, who agreed that it probably represented a new form, and found that he had a similar female in his collection, also from Cuba. When he recently declared his intention to describe these specimens, and asked for the return of the male, again in my hands, I wrote asking his permission to make a study of the male genitalia. The present note is the outcome of that request.

Because the Cuban specimens had three-toothed mandibles, I selected *harrisi*, *elegans*, and *auripes* as suitable for comparison. Acting upon a suggestion of Dr. Fernald, I included *costipennis* as well. This is a species with two-toothed mandibles, of which I studied five specimens collected in various parts of tropical America from Mexico to Brazil. I found that the genitalia of *costipennis* were obviously different from those of the group with three-toothed mandibles. The paramere, though similar in general shape, has a slight instead of pronounced twist at the apex. When it is viewed from an angle perpendicular to its greatest width, the apex is seen to be abruptly pointed, the ventral margin curving toward the tip at a point opposite instead of anterior to the strongest curve in the dorsal margin (see fig. 5). Whereas in *harrisi* and its allies there is a characteristic bevel on the inner surface of the paramere, defined by the ventral margin of the paramere and a mesal ridge which follows the ventral boundary of the thinly sclerotized area, in *costipennis* this bevel, at least toward the apex, is weakly developed. Furthermore, there is a distinct difference in the prominence of the group of thick, tapering hairs situated on the outer surface along the ventral margin anterior to the apical curve. Though variable in size and number, in *harrisi* and its relatives these conical hairs are more or less obscured by other, more slender hairs in the same general area. In *costipennis*, however, they stand out very clearly because the slender hairs are less abundant, and taken as a whole, not so long.

The examination of the genitalia of one male of *exornatum* (Fernald) from Tampa, Florida, which I happened to study because of its being incorrectly identified as *auripes*, showed that the above distinctions may have wider significance than at first appears and may be correlated, at least in part, with the two- and three-toothed condition of the mandibles. The parameres of this specimen of *exornatum* (a species with two-toothed mandibles) differ from those of the *costipennis* I have

studied in that the area on the outer surface above the large conical hairs is densely instead of sparsely haired, the hairs being longer than in *costipennis*, and also in that, posterior to the curve of the ventral margin, the bevel is sharply defined. Nevertheless, on the basis of the genitalia

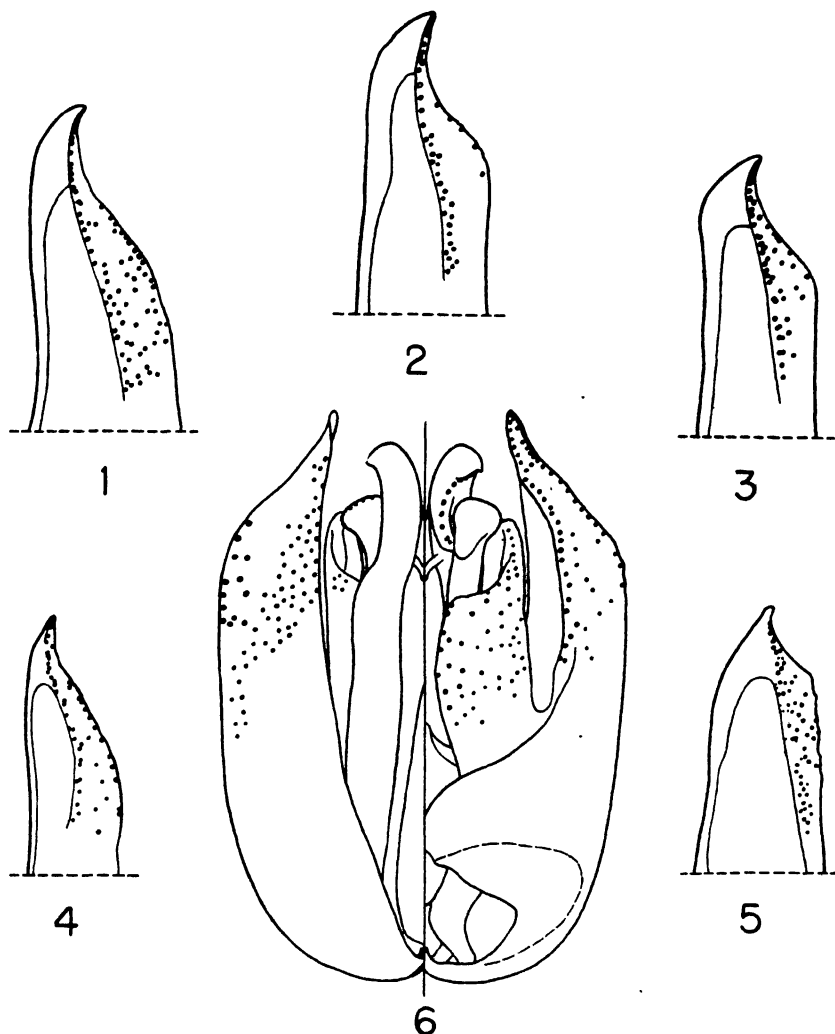


FIG 1. Apical half of left paramere (inner surface) of *Chlorion (Isodontia) auripes*, White Plains, New York. 2. Same of *Chlorion (Isodontia) bruneri*, allotype, Viñales, Cuba. 3. Same of *Chlorion (Isodontia) harrisi*, Tampa, Florida. 4. Same of *Chlorion (Isodontia) elegans*, Umatilla County, Oregon. 5. Same of *Chlorion (Isodontia) costipennis*, Prieta, Honduras. 6. Male genitalia of *Chlorion (Isodontia) bruneri*, allotype, Viñales, Cuba. Left half, dorsal surface; right half, ventral surface. The basal ring is omitted, but its attachment is indicated by the interrupted line on the ventral surface of the base of the paramere.

as a whole, there is no question that this specimen belongs in the same group as *costipennis*.

Though I have studied only four *harrisi*, five *elegans*, and four *auripes*, besides the allotype of *bruneri*, all the specimens of these forms with three-toothed mandibles were found to have nearly identical male genitalia, the most significant differences appearing to lie in the shape of the paramere. This structure, however, is so twisted toward the apex and assumes such a variety of positions in cleared material that until it is dissected from the remainder of the genitalia and so mounted that at least the apical half lies perfectly flat, its use to separate the forms is practically out of the question. Even then, although the distal half has a more or less characteristic outline (see figs. 1-4), the differences seem to be in the nature of variations which are only partially correlated with the named forms. For example, in a test in which I attempted to conceal the identity of the mounted parameres, one specimen of *harrisi* was placed as *auripes* because it lacked the sharp angle in the ventral margin, and the separation of the specimens of *elegans* and *auripes* was not only dubious but incorrect. The paramere of the allotype of *bruneri* appears to lie within the limits of variation of that of *harrisi*.

Other attempts to find distinctions in these genitalia were equally disappointing. Take, for example, the measurements given in the following table.

	Length of paramere divided by greatest width of lamina volsellaris				
<i>bruneri</i> .....	6.4				
<i>harrisi</i> .....	5.5	6.0	6.2	7.2	
<i>elegans</i> .....	5.7	6.0	6.2	6.3	7.1
<i>auripes</i> .....	5.1	5.6	5.8	6.1	

From these negative results I am forced to conclude that the genitalia of the single available specimen of *bruneri* do not offer a valid basis for its separation from the North American forms with three-toothed mandibles, especially *harrisi*.

I am much indebted to Mr. Bruner, Dr. Fernald, and various members of the Bureau of Entomology and Plant Quarantine for favors received during the preparation of this note.

HANDBOOK OF ECONOMIC ENTOMOLOGY FOR SOUTH INDIA, by T. V. RAMAKRISHNA AYYAR. Pp. xviii and 528, illust. 1940. Published by MADRAS (Superintendent, Government Press). Price Rs. 4. 12. 0.

The author of this volume, T. V. Ramakrishna Ayyar, was for some time Government Entomologist of Madras, India. He has brought together facts from his previous publications and has rounded out a general volume on the economic entomology of South India. In a general way this volume succeeds "Some South Indian Insects" by T. Bainbrigge Fletcher which appeared in 1914. The first part of the volume of eighty-five pages covers general entomology, while the second part of 450 pages deals with economic insects and problems. (From the Proceedings R. E. S., London.)—C. H. K.

# FEEDING HABITS OF THE SOUTHERN ARMYWORM AND RATE OF PASSAGE OF FOOD THROUGH ITS GUT

HAMBLIN H. CROWELL,<sup>1</sup>

Department of Zoology and Entomology,  
The Ohio State University.

In a recent article (Crowell, 1941) the writer reported his findings on the utilization of certain foodstuffs by larvae of the southern armyworm. The work was done with larvae reared in the Department of Zoology and Entomology at the Ohio State University under the conditions developed and described by Waters (1937).

The present paper deals with observations made on such physical activities as the ingestion and passage of natural food matter through the alimentary canal of southern armyworm larvae.

## FEEDING HABITS

The southern armyworm is a very general feeder, the foliage of certain legumes and crucifers being particularly preferred. Out of curiosity, milkweed and tobacco foliage were given larvae in the laboratory. It was found that larvae of several instars would feed on the tobacco leaves, but only those of the sixth and last instars would eat milkweed, and then only sparingly.

In the experiments described below, the first leaves arising from the cotyledons of cranberry beans (London Horticultural Variety) were used as food for the larvae. These leaves are succulent (89% water content), nutritious, and are devoured with avidity by all instars of the southern armyworm.

Observations were made through a binocular microscope (90x) on the feeding of newly hatched larvae from an egg mass placed on the surface of a bean leaf. At this magnification the pubescence of the leaves is strongly apparent. It was observed that the larvae feed for several hours on the spines and hairs making up this pubescence. Later, before entering the second instar, the larvae feed on the leaf tissue between the veins, usually leaving intact the epidermis on the other side of the leaf. Larvae of later instars eat more and more of the whole leaf until, in the sixth instar, even the primary veins are consumed. Larvae of the fifth and sixth instars usually start the consumption of a leaf at its margin, the crescent shape of the devoured area being characteristic of leaf-eating larvae.

Lepidopterous larvae have been described as continuous feeders. This assertion is not exactly correct. Extended observations of undisturbed, normal southern armyworms showed that they alternate feeding periods with periods of quiescence. These resting periods are quite distinct from the long quiescent stage prior to molting from one instar into the next.

<sup>1</sup>Dr. Crowell's present address is Box 802, Ancon, Canal Zone.



Preliminary observations were made on three larvae at different times and record was made of the time when feeding started and stopped and the moments when defecation occurred. This record in graphic form appears in figure 1. The sections representing feeding and resting periods are labeled as such, and the times of defecations are denoted by broken cross-lines with the letter "D" inserted. Absolute times are marked off in hours and  $7\frac{1}{2}$  minute intervals.

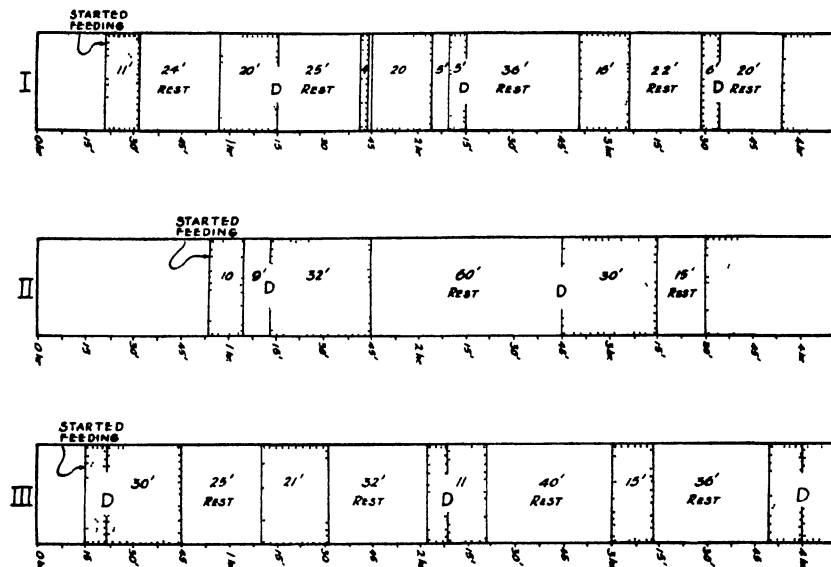


Fig. 1. Graphic representation of the periods of resting and feeding of three sixth-instar larvae of the southern armyworm over a period of about 4 hours. The broken cross-lines marked "D" represent times of defecation.

From this graph it can be seen that the resting periods of these three larvae are as important (judging solely from their frequency and duration) as the feeding periods in the physiology of the insect. With larvae I and II the acts of defecation seem to be connected in some manner with the change from a period of feeding to one of resting or vice versa. With larva III, however, the acts of defecation had no apparent connection with other activities of the insect.

The foregoing 4-hour observations suggested the desirability of repeating the observations over a 24-hour period as follows:

**Methods.**—Three larvae of the 5th instar and three of the 6th were taken from the general culture in the act of feeding. One of the 5th instar larvae later proved to be too old as it ceased feeding preparatory to molting three hours before the experiment was completed. These six larvae were then placed in Petri dishes containing fresh bean leaves and so arranged on a table that they, together with a thermometer and a clock, could be watched continuously without undue strain on the part of the observer. A desk lamp was kept burning throughout the 24-hour period. The temperature ranged between  $22^{\circ}$  and  $26^{\circ}$  C.

The experiment was started at 6:30 A. M., March 28, 1940. Observations were almost continuous, the writer being relieved for several hours by his wife. Twice during the 24 hours the covers of the Petri dishes were removed carefully in order to add fresh leaves and remove fecal matter.

*Results and Discussion.*—The data collected are arranged in two tables. In Table I are presented the comparative figures and averages of the lengths of time spent in the feeding and resting periods and in periods of wandering around. The average length of a wandering period was not considered significant since these periods did not occur at all with two larvae and were generally very irregular.

TABLE I

THE RELATION OF LENGTH OF TIME SPENT IN FEEDING, RESTING AND WANDERING OF SIX LARVAE OF THE 5TH AND 6TH INSTARS OF THE SOUTHERN ARMYWORM OVER A 24-HOUR PERIOD

Larva	Instar	No. of Eating Periods	Total Eating Time	Average Eating Period	Total Resting Time	Average Resting Time	Total Wandering Time
1	6	30	Min. 766	Min. 25.5	Min. 669	Min. 23.6	Min. 5
2	6	26	609	23.4	831	32.0	0
3	6	36	868	24.1	572	16.3	0
4	5	25	238	9.5	1029	34.3	173
5	5	22	509	23.1	681	29.6	22*
6	5	35	596	17.0	754	22.2	90

\*During the last 228 minutes of the 24-hour observation period, this larva was quiescent, preparatory to molting into the sixth instar.

In the sixth instar larvae No. 1 and 3 spent more time in feeding than in resting; the 5th instar larvae all spent more time in resting than in feeding.

The relation of defecations to the resting and feeding periods is presented in Table II.

TABLE II

THE RELATION OF DEFECATIONS TO FEEDING, RESTING AND WANDERING PERIODS OF SIX LARVAE OF THE 5TH AND 6TH INSTARS OF THE SOUTHERN ARMYWORM OVER A PERIOD OF 24 HOURS

Larva	Total No. of Defecations	No. During Feeding Periods	No. During Resting Periods	No. at End of Feeding Periods	No. at End of Resting Periods	No. During Wandering Periods
1	16	4	4	4	4	0
2	12	8	2	1	1	0
3	16	10	2	3	1	0
4	8	1	2	1	3	1
5	12	4	2	0	6	0
6	13	3	2	3	4	1
Totals.....	77	30	14	12	19	2

Most of the defecations take place during the process of feeding and the next largest number falls at the termination of resting periods. There appears to be no connection between defecation and the beginning or ending of feeding.

Under constant artificial light no diurnal cycle of feeding-resting ratios was observed during the 24 hours. In other words, the feeding-resting periods were about the same day and night.

#### RATE OF PASSAGE OF FOOD THROUGH THE ALIMENTARY CANAL

In studies of the utilization of food it is important to know the length of time required for the passage of food through the alimentary tract of the experimental animal. In the case of southern armyworm larvae, with their straight-tube digestive tracts, it was assumed to be a relatively short period of time.

*Methods.*—For the purpose of determining the rate of passage of ingesta, an indicator was needed for earmarking ingested food. Several dyes were tried, but the results were always obscured by the diffusion of the indicator throughout the food. A paste, made from powdered Bentonite clay and juice from crushed bean leaves, was tried with some success. As soon as a larva was observed to be eating the paste, the clock time was recorded, the larva allowed to feed for five or ten minutes, and then the paste replaced with fresh leaves. Observations were made every few minutes until a defecation finally showed the presence of the light colored clay. The results from several of these tests showed that the late sixth instar larvae pass food through their entire alimentary canal in about  $3\frac{1}{4}$  hours.

When tried on a larger scale with both 5th and 6th instar larvae, certain difficulties arose. The 5th instar and early 6th instar larvae did not feed freely on the indicator paste until starved for two or three hours. This condition of partial starvation was not desirable, and the question also arose as to the effects of clay diet, even of short duration, on the natural functioning of the alimentary canals of these larvae.

It has been found (Crowell, 1941) that the larvae utilize little, if any, starch from their natural food. This fact, together with the knowledge of the color reaction between starch and iodine, led to the use of powdered potato starch as the indicator material.

The starch flour was dusted upon bean leaves which had been previously sprayed lightly with water. Larvae of the 5th and 6th instars were taken from the general culture and allowed to feed for several minutes on the treated leaves, the clock time being recorded. The larvae were then transferred to fresh, untreated leaves in Petri dishes and observed. The time of each defecation was recorded. The fecal pellets were then dispersed in a few drops of dilute iodine in KI solution and examined under the binocular for the presence of starch granules.

*Results.*—The results showed evidence of churning action in the gut of these larvae. From the tightly packed appearance of the food observed in the mid- and hind-guts of dissected larvae, one might imagine that the starch ingested in these experiments would pass

through the alimentary canal in a mass, emerging at last completely enclosed in one or two fecal pellets. Actually, the starch indicator particles were found dispersed throughout a series of fecal pellets evacuated during a five hour period, after the first appearance of the starch. However, the dispersal of the starch granules in these pellets was not uniform, but reached a maximum concentration in about the third pellet defecated and tapered off during the next 4 or 5 hours. Only four larvae were observed until the time of the complete disappearance of the starch granules. Table III shows the elapsed times to the first appearance of the indicator, to the maximum amount, and to the final elimination of the indicator from the alimentary canal.

TABLE III

THE RATES OF ALIMENTATION OF SEVERAL LARVAE OF THE 5TH AND 6TH INSTARS OF THE SOUTHERN ARMYWORM

Exp. No.	No. of Larva	Instar	Time Till First Trace of Indicator		Time Till Maximum Test		Time Till Elimination of Indicator	
			Hr.	Min.	Hr.	Min.	Hr.	Min.
1	1	5th	2	29	3	19		
	2	6th	2	10	4	13		
	3	6th	1	50	3	10		
	4	5th	1	10	2	15		
	5	6th	1	25				
	6	5th	2	10	2	40		
2	1	6th	2	55	4	10		
	2	6th	3	40			6	56
	3	6th	2	3	3	8	8	3
	4	6th	1	18	4	17		
	5	6th	1	10	3	5		
	6	6th	2	3	3	33		
	7	6th	1	52	2	53	6	12
	8	6th	1	44	2	44	7	54
Averages....			2	0	3	17	7	18

It is obvious that observations on the rate of passage of food that are based on the detection of an indicator in the feces cannot help showing considerable variation due to the different degrees of fullness of the recta of the experimental animals at the time of ingestion of the indicator material. The time elapsed for the egestion of the maximum amount of starch indicator, about  $3\frac{1}{4}$  hours, is possibly the most accurate figure obtained for the rate of food passage through the alimentary canal of the southern armyworm. It is interesting to note that this average time agrees perfectly with the preliminary results obtained with the clay and leaf juice paste indicator mentioned earlier in this paper. The clay was possibly too heavy or compact to be dispersed among the leaf fragments to any great extent by whatever churning action may occur in the alimentary tract of these larvae.

## BEAN LEAF INGESTA IN THE FORE-GUT

In dissections of southern armyworm larvae it was noticed that the fore-gut usually contained only the green leaf juice, the leaf particles themselves having passed on into the mid-gut. The green fluid which the larvae regurgitate when disturbed is apparently this same leaf juice from which the solid matter has been removed.

For use in further investigations of the fore-gut activities, a number of 6th instar larvae were selected at random from the general culture. These were placed in Petri dishes with fresh bean leaves and observed. After several individuals had fed continuously for 10 or 15 minutes, they were removed carefully, so as to prevent regurgitation, killed instantly in hot water and dissected immediately under water. Other individuals were allowed to remain in the dishes until they had entered the resting period between periods of feeding. Some were killed and dissected at various periods of time after entering the resting stage, while others were observed until they showed signs of resuming feeding again. At this time they were removed and killed for dissection before they had had time to take more than a bite or two.

The larvae killed and dissected while still in the process of feeding were found to have their fore-guts filled with leaf particles, as was to be expected. The fore-guts did not appear to be as tightly packed with leaf particles as were the mid-guts, but this condition could be partially due to the absence of the confining peritrophic membrane which allowed the leaf particles to float out into the dissecting fluid when the gut was opened.

Every larva killed and dissected at the moment it showed signs of resuming feeding again was found to have no solid particles of leaf matter remaining in its fore-gut. This region of the alimentary canal, however, always contained a good supply of leaf juice. As there is no way of telling how long a given larva will remain quiet before commencing to feed again, it was impossible to determine at just what time in the resting period the food particles are all transferred from the fore-gut into the mid-gut.

The fact that the larvae pass the leaf particles on into the mid-gut and retain much of the liquid in the fore-gut may possibly be explained in the following manner: As the food material within the peritrophic membrane of the mid-gut moves slowly along, it is replaced with the freshly eaten material from the fore-gut by peristaltic action. Here the leaf particles become confined by the peritrophic membrane, but the leaf juice, liberated in some quantity in the process of masticating the rather succulent leaves, is free to pass back again through the oesophageal valve into the fore-gut.

The fact that all leaf particles were observed to have been passed on into the mid-gut before any of the larvae commenced feeding again after a rest period suggests a plausible answer to the alternation of resting and feeding periods. The larvae ingest food faster than it can be digested and passed out of the intestine, a natural condition with most animals when given an unlimited food supply. After feeding for a time, the stimulation of back-pressure from the packed mid-gut and irritation of food particles in the fore-gut causes them to enter a resting

period. Removal of this pressure and irritation sets off the stimulus to commence feeding again.

### SUMMARY

1. Observations are given on the general feeding habits and type of food plants eaten by the southern armyworm.

2. Continuous observations on feeding larvae of the 5th and 6th instars show that during a 24-hour period the larvae spend as much, if not more, time in resting or quiescent stages as they do in feeding periods. These resting periods alternate with the feeding periods and are entirely separate from the quiescent stages prior to molting or pupating. The moments of defecation are most common during the feeding periods and at the termination of resting periods, but also occur at other times.

3. A method for the determination of the length of time required for the passage of food through the alimentary canal of the larvae is described. The 5th and 6th instar southern armyworm require about  $3\frac{1}{4}$  hours for the main bulk of an earmarked quantity of food to pass through the digestive tract.

4. The fore-guts of the larvae are cleared of solid leaf particles during rest periods, but retain much leaf juice at all times. An explanation of the alternation of feeding and resting periods based on these observations is submitted.

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MONOGRAPH OF THE WEST INDIAN BEETLES OF THE FAMILY STAPHYLINIDAE, by RICHARD E. BLACKWELDER. 1943. pp. 1-658; 19 maps, 3 figs. Published by SMITHSONIAN INSTITUTION, U. S. National Museum, Bull. 182.

This complete work was made possible by the Walter Rathbone Bacon Scholarship administered by the Smithsonian Institution. In addition to twenty-one months in the islands collecting specimens, the author examined numerous collections and all authentic West Indian records to date are included.

The study includes 91 genera, 6 of which are new to science, and 468 species, 212 of which are described as new. Keys are given to 12 subfamilies and to genera and species. Descriptions and synonymy of all species are given. Nineteen full page maps showing collecting areas are included and, unfortunately, only three cuts showing 17 genitalia figures.—J. N. KNULL.

# SWIMMING AND BURROWING ACTIVITIES OF MAYFLY NYMPHS OF THE GENUS *HEXAGENIA*<sup>1</sup>

F. EARLE LYMAN,

Assistant Aquatic Biologist, Tennessee Valley Authority,  
Norris, Tennessee

The fact has already been established by bottom fauna studies (Adamstone, 1924; Rawson, 1930; Neave, 1932) that lake dwelling species of *Hexagenia* are inhabitants of soft, organic muds of deeper-water areas contiguous to the shallower sandy or rocky littoral region. Although specimens may be found on a sandy bottom or on a bottom of fine sand and mud intermixed, by far the greater numbers occur on bottoms of a distinctly soft, muddy character. As no investigations have been made on the ability of *Hexagenia* to burrow in various kinds of bottom, and since the character of the bottom is considered by the writer to be of primary importance as a factor influencing distribution of these nymphs as found in Douglas Lake, Cheboygan County, Michigan, a series of experiments was conducted.

## FREE-SWIMMING ACTIVITIES

*Hexagenia* nymphs are not strong, agile swimmers. Their swimming ability is easily shown by artificially circulating the water in an aquarium containing specimens. The nymphs appear passively rheotropic, orienting themselves as best they can facing against the current, at the same time performing the characteristic swimming movements and even then they are carried along almost completely at the mercy of the current. In swimming the nymphs hold the fore legs together anteriorly. The fore tarsi touch each other on the median line just anterior to the mandibular tusks. The middle legs are directed anteriorly, held close to the sides of the thorax and head, and overlap the bases of the fore legs. The hind legs are directed posteriorly, and are held arch-like, but closely pressed to the dorsum of the first three abdominal segments, and the distal tips of the femora almost touch over the middorsal line. The head and thorax are usually arched ventrally thus causing the anterior portion of the body to be directed downward. In a dish containing water this usually results in the nymph constantly striking the bottom of the container or swimming along with the fore legs touching and with the waving abdomen at a slight angle above the bottom. The nymph may turn to the right or left by tilting the body slightly toward the opposite side. Should the nymph in swimming turn entirely over on its back, it leaves the bottom and comes toward the surface. This tilting or turning over of the body at times results in a circular or corkscrew path. If the nymph, while swimming in a straight line, elevates the head and thorax slightly, the course changes to upward or becomes parallel to and just above the bottom. The lateral tails, ordinarily spread apart at about a 45° angle with the

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<sup>1</sup>Contribution from the Biological Station and Department of Zoology, University of Michigan.

median line when the nymph is at rest, appear to be a distinct aid in swimming. During the first swimming movements the outer tails are brought together toward the median one thus causing the setal fringes of all three to overlap and forming a more proficient propelling structure. The bringing together of the lateral tails seems to be carried out by intentional muscular movement on the part of the nymph preparatory to swimming and is not due wholly to current pressure from the sides of the nymph as it passes through the water. Swimming is accomplished through strong dorso-ventral undulations of the abdomen. The abdomen was not observed to sway laterally.

The gills are waved during swimming. These waves begin anteriorly and progress posteriorly. The gill movements made in swimming are not identical to those made while the nymph is resting. In swimming the gill motion appears to be a result of abdominal movements as a whole and not due to contractions of the gill muscles used to move them when the body is at rest. The gills do not extend laterally at right angles to the body when the nymph is at rest or swimming, but are directed upward and curved posteriorly straight back over the abdomen or slightly toward the middorsal line.

### BURROWING ABILITY

A large, deep aquarium containing water was supplied with soft bottom mud from about 13 m. depth and allowed to settle. The resulting bottom deposit was then further consolidated by gently jarring or shaking the aquarium from side to side. As a result the heavier particles settled through toward the bottom while the lighter, more or less flocculent materials remained near the top, thus more closely simulating natural conditions in the lake. After the mud had thoroughly settled and the surface-water had cleared, a number of nymphs, one-half to three-fourths grown, were introduced and their activities observed. These nymphs immediately settled gently to the surface of the mud and began swimming by means of strong, undulating, dorso-ventral movements of the abdomen. The fore and middle legs were held together anteriorly, and the head and thorax were directed downward. While swimming in this manner the body is so tilted that the anterior end is slightly lower than the posterior, consequently, entrance into the mud was made. Digging motions by the fore legs were then begun, and the strong, steady, undulating abdominal movements ceased, except for occasional waves which propelled the nymph forward at intervals after the way had been cleared by the fore legs. The gills were kept in constant motion during the digging process, producing a current of water which passed posteriorly over the body and out through the burrow opening. Mud particles thrown backward by the fossorial legs were picked up by this current and transported from the burrow. After burrowing to a depth of 10-15 cm., most of the digging movements were suspended and only gill motion continued. As long as the legs were in motion the sides of the burrow constantly caved in and the loosened particles were carried out by the water current. This caving in subsided as soon as the leg movements ceased. However, the mud in front of the nymph continued to be drawn backward over the gills by the current and carried out through the burrow



opening behind the insect. The gill movements at this time became perceptibly stronger, thus causing the mud particles directly in front of the nymph to be drawn toward it and swept by the current over its back. As this process continued, a caving in of the mud from the surface along an upwardly curved line was initiated. A current of water was finally produced in front of the nymph along this curved line which cleared a passageway in the mud and formed the anterior portion of the burrow. The water current also provided the nymph with a source of oxygenated water. The front and back ends of a burrow were easily distinguished since the former had a smoothly rounded edge, while the posterior one had a small mound of mud surrounding it. Branches from the original burrow were made in much the same manner. Nymphs were not observed to leave their burrows to come to the mud surface either during the day or at night. Attempts to make artificial tunnels in the mud by the insertion of various objects met with no success, for as soon as the object was withdrawn, no matter how slowly and gently, the sides immediately caved in. A short time after a nymph had deserted a burrow for a branch or if gill movements were suspended for a time, collapse of the walls occurred. The burrow was cleared of mud again when gill movements were resumed.

In order to determine the ability of nymphs to burrow into various kinds of bottom found in Douglas Lake, the following experiments were performed:

*Experiment No. 1.*—Clean sand, collected near the shore line, was placed in a large culture dish and covered with water. Several medium-to large-sized nymphs were introduced into it. They immediately began the typical swimming movements as described above, trying to gain entrance into the sand. All efforts to penetrate the sand were futile and, as the nymphs grew progressively tired, swimming gradually slowed down and finally ceased. They remained quiet for a short time, moving the gills intermittently and making no effort to hold to the sand with their claws. They were easily pushed to one side or turned completely over by another nymph swimming by and usually made no effort to right themselves at the time. After some time, swimming was resumed and further burrowing efforts were made. Some nymphs would occasionally stop swimming and begin digging with the fore legs, pushing the sand grains laterally. However, very little headway was made due to the constant tumbling of the sand grains back into the small depression as it was deepened. A solid footing for thrusting the head into the depression could not be obtained on the loose sand. Undulations of the abdomen were of no aid to the nymph in forcing the anterior portion of the body into the sand.

When a small stone (1–3 cm. diameter) was placed on the sand, a nymph coming in contact with it began to burrow. By the united efforts of digging with the legs, thrusting the head under the stone by abdominal movements, pushing downward with the dorsum of the thorax braced against the underside of the stone, and pushing with the hind legs, a cavity was made sometimes large enough to conceal only the head and thorax leaving the abdomen exposed, at other times large enough to conceal the entire body of the nymph. The nymph then remained in this cavity for a time, usually making no further attempts to burrow. Another nymph, trying to burrow in the same

place, either forced the first one to leave its burrow or caused it to move further on under the sand until it was no longer under the stone. In this event the latter did not remain completely submerged but came close enough to the surface so that the gills were exposed and might be moved freely leaving the rest of the body still covered by a thin layer of sand grains. A nymph covered in this manner remained thus for some time but would ultimately break out and begin swimming around the dish again in seeming effort to find a more suitable environment.

If covered artificially with sand, a nymph usually remained quietly submerged for a short period and very little if any gill movement was observed. Finally digging started and the nymph came up near the surface of the sand as described above. When covered by a thick layer of sand, the nymph did not escape by digging and soon died.

*Experiment No. 2.*—In order to determine if the size of sand grains were significant in the ability of the nymphs to burrow, some of the sand from the first experiment was sorted by means of a 35 mesh (opening 0.417 mm.) Tyler Standard Scale screen into two grades: (1) sand retained by the 35 mesh screen, and (2) sand which passed through it.

TABLE I

## PHYSICAL ANALYSIS OF BOTTOM MATERIALS, EXPERIMENT NO. 3

Sample of 500 cc. washed through a set of 6 Tyler Standard Scale screens.  
Measurements of wet volume. Loss in washing, 35 cc.

Mesher per Inch	Size of Mesh in mm.	Materials Retained by Screen in cc.	Percentage of Total	Materials
4	4.699	2	0.4	Shells and sticks
8	2.362	4	0.8	Large marl flakes
14	1.168	18	3.6	Mostly marl flakes
35	0.417	128	25.6	Coarse sand and marl
65	0.208	275	55.0	Fine sand and marl
100	0.147	33	6.6	Very fine sand and marl
Pan	.....	5	1.0	Finest sand and marl

It was found that nymphs could not burrow into either of these two grades of clean, sorted sand. Their reactions on both grades were the same as described in the first experiment.

*Experiment No. 3.*—Since nymphs were sometimes found in more or less sandy areas in shallow water, their burrowing ability in this type of bottom was tested. A sample of sand was collected at a depth of 1.5 m. from a place where the nymphs were known to occur. Nymphs were placed on this sand in a large culture dish containing water. They had some difficulty burrowing into the sand but all of them finally gained entrance and remained under it. From one end to the other, the burrows were made almost entirely by digging with the fossorial legs and were relatively short and shallow. The time required to complete a burrow was longer than it was for those made in mud. A 500 cc. sample of this sand was then graded by means of a set of six Tyler Standard Scale screens in order to determine more exactly the composition of the sand. From the data given in Table I, it may be seen that the principal constituent, other than sand, is marl.

That sand and marl retained by the 35 mesh screen and that which passed through were used for further experiments. It was found that nymphs could burrow very readily into the fine sand and marl which passed through the 35 mesh screen. However, only about 50 per cent of the nymphs placed on coarse sand and marl retained by the 35 mesh screen could burrow into it by deliberate digging movements.

Clean sand was placed in a dish and covered with a layer of marl. It was found that nymphs burrowed into the marl but not into the sand layer below. If the same sand and marl were intermixed, the nymphs burrowed readily into the mixture.

*Experiment No. 4.*—Between the sandy bottom in shallow water and the muddy bottom of deep water, a zone occurs in which the sand and mud are intermixed, and the mud forms a comparatively thin layer on top. Dredgings were taken in this intermediate zone at 6–10 m. water depth. This material was placed in a dish containing water and the sand settled quickly to the bottom allowing a layer of mud to form on top. When nymphs were placed on this sandy mud, they burrowed into it readily. A 500 cc. sample of this same mud was graded using the

TABLE II

## PHYSICAL ANALYSIS OF BOTTOM MATERIALS, EXPERIMENT NO. 4

Sample of 500 cc. washed through a set of 6 Tyler Standard Scale screens.  
Measurements of wet volume. Loss in washing, 56 cc.

Mesher per Inch	Size of Mesh in mm.	Materials Retained by Screen in cc.	Percentage of Total	Materials
4	4 699	3	0 6	Wood
8	2 362	4	0 8	Wood, shells, stones
14	1 168	6	1 2	Wood, small stones
35	0 417	140	28 0	Coarse sand, organic debris
65	0 208	253	50 6	Fine sand, organic debris
100	0 147	27	5 4	Very fine sand, organic debris
Pan	.....	11	2 2	Finest sand, organic debris

Tyler screens. The results are given in Table II and show that finely divided organic detritus is the main constituent other than sand.

Clean sand was then placed in a dish and covered with a layer of mud with no intermixing of the sand and mud. Nymphs placed on this burrowed into the mud but only one specimen was observed to enter the sand layer. When this same sand and mud were thoroughly mixed, nymphs easily burrowed into it.

## DISCUSSION

The series of experiments described above show that the character of the bottom is one of the most important environmental factors influencing the distribution of *Hexagenia* nymphs.

Morgan and Grierson (1932) seem to have definitely established experimentally that the tracheal gills of *Hexagenia recurvata* Morgan are respiratory organs and that nymphs from which the gills had been removed showed little or no efforts to burrow but remained on the surface of the mud. Wingfield (1939) in his discussion of the experi-

mental work on the respiratory function of the tracheal gills of mayfly nymphs, stated that, "nothing is known of any relation between function and habitat."

At least two important functions of the gills of *Hexagenia*, besides respiration, have been brought out in the author's experimental work. First, they are used indirectly to build the anterior portion of the burrow made in mud and to keep the entire passageway clear of mud particles once it is built. The fact that the walls of the burrow begin to collapse after gill movements cease seems to indicate that the integrity of the burrow is somehow dependent upon the current of water. It may be true that in the natural environment the compactness or adhesive quality of the mud is sufficient to sustain the walls of the burrow at depths greater than 8-10 cm. from the mud surface. However, the uppermost stratum of mud in Douglas Lake is almost always composed of flocculent, semisuspended particles which do not possess the compactness of the deeper mud. Second, the gills insure a more or less steady supply of oxygenated water for use in respiration. The oxygen supply in the water surrounding the nymph would undoubtedly be rapidly exhausted were it unable to renew the supply of water. It was stated under Experiment No. 1 that when a nymph was covered by sand, the gills did not move freely. This was due to the weight of the sand particles which constantly fell back onto them almost as soon as they were pushed away; consequently, the nymph was forced to come to the surface or suffocate. In Morgan and Grierson's work, it may be that the reason the nymphs made no effort to burrow after their gills had been removed was because they had no means of obtaining a fresh supply of water in the burrow and would therefore suffocate. Also, without gills they would have no way of keeping the burrow clear, even if they could build it.

It is known that the nymphs of *Hexagenia* do not occur in the profundal regions of Douglas Lake (Eggleton, 1931), and they do not extend beyond 15 m. depth. This is also substantiated for other large bodies of water in the bottom fauna studies of Adamstone (1924), Rawson (1930), and Neave (1932). One of the significant reasons for this limited depth distribution seems to be indicated by the dissolved oxygen relations in the South Fishtail depression of Douglas Lake. From the physico-chemical data published for Douglas Lake by Welch (1928), and Welch and Eggleton (1932; 1935), it may be seen that in the South Fishtail depression, beginning about the first of July and continuing through the summer, the normal limits of the thermocline vary within about 12 to 16 m. In these data it is also shown that there is a distinct and rapid drop in the dissolved oxygen content of the water between the upper and lower limits of the thermocline, the oxygenless zone usually beginning at about 20 m. Thus, there appears to be a correlation of the habitat occupied by the nymphs (11-13 m.) with the limits of the thermocline and the amount of dissolved oxygen present. From the selected data given for the years 1929-1933 (Welch and Eggleton, 1932; 1935) the average drop in dissolved oxygen within the thermocline limits was 4.4-1.4 cc. per liter. Therefore, at depths greater than 15 m. the nymphs in their burrows would have difficulty obtaining sufficient oxygen from the available water. The character of the bottom materials beyond 15 m. is not

sufficiently different to lead one to the conclusion that this alone would preclude the nymphs from migrating into greater depths.

The preceding experiments also show that the nymphs cannot burrow into clean sand taken from the wave-washed area just below the water line but can burrow into marly or muddy sand taken at greater depths. When the marly and muddy sand grains were carefully examined under a microscope, their otherwise smooth surfaces were found to be coated with a thin layer of either marl or fine particles of mud. Thus, the marl and mud appear to act as binders or adhesives holding the grains in place and preventing them from falling back into the burrow once it is cleared. In the instance of the clean, more or less smooth sand grains there is nothing to hold them in place after they are piled up during the digging process. Consequently, they fill the depression as fast as it is dug. Tables I and II show that by far the greater proportion of the sand-marl or sand-mud was of the finer type, and therefore more suitable to the nymphs for burrowing than the coarse sand-marl or sand-mud. The fact that when the clean sand was mixed with either marl or mud, the nymphs could readily burrow into it further supports the conclusion that marl or mud affects the character of the sand in some way which renders it suitable for burrowing.

#### SUMMARY

1. Free-swimming and burrowing activities of *Hexagenia* nymphs are described in general.
2. Gills are used for burrow construction and to maintain a more or less constant current of water through the burrow once it is built.
3. Burrowing experiments performed with nymphs on various kinds of bottom show that the character of bottom is one of the most important factors influencing distribution of *Hexagenia* nymphs.
4. The greatest water depth at which *Hexagenia* nymphs occur in Douglas Lake is correlated with dissolved oxygen relationships within the thermocline.

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# THE ARANEIDA FOUND ON COTTON IN CENTRAL TEXAS

MARTIN KAGAN,<sup>1</sup>

Waco, Texas

While working for the United States Department of Agriculture, Bureau of Entomology and Plant Quarantine, Division of Cotton Insect Investigations, at Waco, Texas, the writer encountered numerous species of spiders in examining cotton for insect damage. Most of these spiders are little known and receive only casual notice. Some of them were found to be predators on insects which damage the cotton plant or its fruit.

The predatory habits of spiders are beneficial in the control of insect pests and when spiders are found in large numbers in an area of great insect population, it is only natural to suspect that the spiders are feeding on the insects and decreasing the population. Bishop and Hart (1931) found spiders of the family Lycosidae feeding on mosquito larvae. Jones (1940) observed spiders of the genus *Dictyna* eating craneflies and leaf hoppers. Bilsing (1920) found that *Adelphocoris rapidus* (Say) was eaten by spiders in the families Lycosidae, Attidae, Clubionidae, Pisauridae, Agelenidae and Epeiridae.

The writer did not find any species of spider feeding on the boll weevil (*Anthonomus grandis* Boh.) which would indicate that this insect's hard body covering and large size was too difficult for most spiders to overcome. The smaller cotton pests which have softer body coverings were, however, found to be attacked. The following table shows the spiders observed feeding on cotton insects.

TABLE I  
SPIDERS OBSERVED FEEDING ON COTTON INSECTS

	<i>Adelphocoris rapidus</i> (Say)		<i>Psallus serialus</i> Reuter		<i>Aphis gossypii</i> Glover	<i>Heliothis armigera</i> (Fab.)	<i>Alabama argillacea</i> (Huebner)
	Adults	Nymphs	Adults	Nymphs	Nymphs	Larvae	Larvae
<i>Misumenops celer</i> .....			x			x	x
<i>Misumenoides aleatorius</i> .....	x					x	x
<i>Argiope aurantia</i> .....		x	x			x	
<i>Tetragnatha laboriosa</i> .....			x		x		
<i>Phidippus variegatus</i> .....	x					x	x
<i>Wala palmarum</i> ..	x	x	x	x			
<i>Aysa gracilis</i> ..			x		x		
<i>Mimetus hesperus</i> ..			x	x	x		
<i>Oxyopes salticus</i> ..	x		x				

<sup>1</sup>Senior in the School of Veterinary Medicine, A. & M. College of Texas.

List of Spiders collected from cotton during the Summers of 1941-42.<sup>2</sup>

## DICTYNIDAE

*Dictyna segregata* Gertsch and Mulaik  
*Dictyna longispina* Emerton

## MIMETIDAE

*Theridion murarium* Emerton  
*Latrodectus mactans* Fabricius

## MICRYPHANTIDAE

*Grammonota texana* Banks

## ARGIOPIDAE

*Neoscona eximia* Gertsch  
*Neoscona minima* Cambridge  
*Neoscona vertebrata* McCook  
*Acanthepeira stellata* Walckenaer  
*Eustala anastera* Walckenaer  
*Tetragnatha laboriosa* Hentz  
*Argiope aurantia* Lucas  
*Mangora gibberosa* Hentz  
*Mimognatha foxi* McCook  
*Gea heptagon* Hentz  
*Aranea* sp.

## OXYOPIDAE

*Peuceha viridans* Hentz  
*Oxyopes salticus* Hentz

## CLUBIONIDAE

*Chiracanthium inclusum* Hentz  
*Clubiona kagami* Gertsch

## ANYPHAENIDAE

*Ayscha gracilis* Hentz

## THOMISIDAE

*Misumenops celer* Hentz  
*Misumenops dubius* Keyserling  
*Misumenoides aleatorius* Hentz  
*Xysticus funestus* Keyserling  
*Philodromus infuscatus* Keyserling  
*Ebo* sp.

## SALTICIDAE

*Phidippus texanus* Banks  
*Phidippus variegatus* Lucas  
*Paraphidippus marginatus* Walckenaer  
*Metaphidippus insignis* Banks  
*Metaphidippus vilis* Cockerell  
*Sassacus papenhoei* Peckham  
*Wala palmarum* Hentz  
*Pellenes coronatus* Hentz  
*Marpissa undata* DeGeer

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 Bishop, S. C., and Hart, R. C. Notes on Some Natural Enemies of the Mosquito in Colorado. 39: 151-157.  
 Jones, Sarah E. 1940. An Annotated List of the Spiders of an East Central Illinois Forest. *Trans. Ill. Acad. Sci.*, 33: 216-220.

<sup>2</sup>Collections were made in Falls, McLennan and Limestone Counties.

THE CRAYFISHES OF FLORIDA, by HORTON H. HOBBS, JR., Pp. v and 179, 24 pls. (346 figs.), 8vo., 1942. Paper bound. Published as Vol. III, No. 2. Biological Science Series of University of Florida, Gainesville, Fla.

We call attention to this monograph, an excellent and thorough-going piece of work which is well illustrated, because it reviews, pages 9-22, practically all the important work that has been done on distribution, migration routes and ecological areas in the peninsula of Florida and its source of faunal supply to the southern Georgia coast. Odonatists have recognized for some time that Florida had a pocket fauna of endemic species. It is a vacation ground for collectors. Distribution of insects there and the origin of the peculiar species are rapidly becoming a marked minor problem in insect species study. The pages cited state the parts of the problem and cite the literature on the subject.

Incidentally it brings back those thrills of boyhood days when another kind of crayfish had just been pulled out of a hole or had been captured under a chunk in a bottom-land slough. And then the first sight of cave crayfish: Florida has several.—C. H. K.

# A TAXONOMIC AND DISTRIBUTIONAL STUDY OF SIMULIIDAE OF WESTERN UNITED STATES<sup>1</sup>

G. S. STAINS AND G. F. KNOWLTON,<sup>2</sup>

Utah Agricultural Experiment Station,  
Logan, Utah

Simuliidae, usually called black-flies or buffalo gnats, are abundant both as individuals and species in Utah and other western states.<sup>3</sup> The present report is an outgrowth of the study of blood-sucking flies and began at the time when equine encephalomyelitis was killing a large number of horses in Utah. It is known that certain diseases and parasites are transmitted through the feeding of female Simuliidae, and these frequently feed in large numbers on horses, other livestock, wild life and even annoy man. The species and distribution of these economically important pests are incompletely known in the west. Only material collected west of the Mississippi River is included, the bulk being taken from the Rocky Mountain area; most of this material is deposited in the Utah Agricultural Experiment Station insect collection.

This study is based on external and internal characters of adult specimens. The writers followed Dyar and Shannon in use of the stem-vein character (fig. 1), Edwards and Twinn in use of calcipala or projection on apex of hind basitarsi (fig. 2), and pedisulcus or dorsal incision on hind second basitarsi (fig. 2). The use of male terminalia for taxonomic characters was first used for this family in America by Pomroy, in 1916. The use of female genitalia is comparatively recent, first being used by Dyar and Shannon in 1927.

<sup>1</sup>Contribution from the Department of Entomology, Utah Agricultural Experiment Station, Logan.

<sup>2</sup>Graduate research assistant and research associate professor, respectively.

<sup>3</sup>Available material consisted of several thousand mounted and many thousand unmounted traplight specimens collected in Utah. In addition the writers are indebted to the following entomologists and institutions that lent material for study: Dr. R. H. Beamer of the University of Kansas; E. S. Ross of the California Academy of Sciences; Dr. R. H. Painter of Kansas State College; Prof. H. C. Severin of the University of South Dakota; Prof. J. N. Knull of Ohio State University; Dr. M. T. James of Colorado State College; Dr. H. B. Mills of Montana State College; Dr. W. R. Salt of the University of Alberta; Dr. H. H. Ross of Illinois Natural History Survey; L. S. Lipovsky of State College of Washington; F. C. Harmston of Utah State Agricultural College. Special thanks are due Dr. A. Stone of the U. S. Bureau of Entomology and Plant Quarantine, for comparing western specimens with types in the National Museum, for rendering opinions on synonymy and for suggestions concerning the manuscript; to the U. S. National Museum for the loan of several species needed to complete this study; and to Dr. C. R. Twinn of the Canadian Division of Entomology, for the loan of comparison specimens and for suggestions.



## TAXONOMY

## KEY TO GENERA OF SIMULIIDAE

1. Radial sector simple, not forked (*E. osborni* has a weak fork); antennae always 11-segmented; radius may be setose its entire length or bare at base; calcupala and pedisulcus usually present. . . . . 2
- Radial sector with a long fork, antennae 9- to 11-segmented; radius always setose its entire length; calcupala and pedisulcus absent. . . . . 3
2. Radius setose its entire length; pedisulcus and calcupala present or absent, usually a large thumb-like projection at base of claws; fore tibiae without silver pilosity. . . . . **Eusimulium**
- Radius plain, not setose its entire length; pedisulcus and calcupala always present; claws seldom with a thumb-like projection at base; usually a silver pilosity on fore tibia. . . . . **Simulium**
3. Radius joining costa far beyond middle; antennae rarely 10-segmented, . . . . . **Prosimulium**
- Radius joining costa in middle; antennae 10-segmented (rare). . . . . **Parasimulium**

Genus **Parasimulium** Malloch

*Parasimulium* Malloch, U. S. Dept. Agr., Bur. Ent. Tech. Ser., No. 26, p. 24, 1914.

Only a single specimen is known for this genus and the monotypic species it contains. There has been a difference of opinion regarding the sex of this specimen. Malloch, in his original description, records it as a female; Knab considered it to be a male (Insec. Insc. Men., 2 : 150, 1914). Stone (Proc. Ent. Soc. Wash. 43 : 146-149, 1941) dissected out the internal genitalia, proving it to be a male.

**Parasimulium furcatum** Malloch

*Parasimulium furcatum* Malloch, U. S. Dept. Agr., Bur. Ent. Tech. Ser. No. 26, p. 25, 1914.

A small brownish species; frons broad; clypeus narrow; antennae yellow, 10-segmented; legs yellowish; calcupala and pedisulcus absent; pleurae yellowish; radial sector with a long wide fork; radius joining costa at its middle.

*Type locality*.—Humbolt County, California. Type in U. S. National Museum.

Genus **Prosimulium** Roubaud

(Figure 1)

*Prosimulium* Roubaud, Compt. Rend. Acad. Sci. Paris, 143: 519, 1906.

With few exceptions, species of this genus come from higher and colder altitudes. Medium to large species; claws usually simple, seldom possessing a thumb-like projection at base; antennae with 9 to usually 11 segments; pedisulcus and calcupala always absent; radial sector with a long branch; radius setose over its entire length; front and clypeus usually broad.

Genotype, *Simulium hirtipes* Fries.

## KEY TO THE FEMALES OF PROSIMULIUM

1. Integument yellow. . . . . 2
- Integument black. . . . . 3
2. Claws with large thumb-like projection at base; frons narrow. . . . . **onychodactylum**
- Claws simple; frons broad. . . . . **fulvum**

- |  |                      |
|--|----------------------|
| 3. Claws with thumb-like projection at base. . . . .                   | <b>pleurale</b>      |
| Claws simple. . . . .  | 4                    |
| 4. Antennae with 11 segments (basal segment sometimes hidden). . . . . | 5                    |
| Antennae with less than 11 segments (rare). . . . .                    | 6                    |
| 5. Antennae wholly yellow. . . . .                                     | <b>flaviantennus</b> |
| Antennae at most with basal two segments yellow. . . . .               | 7                    |
| 6. Antennae 10-segmented. . . . .                                      | <b>unicum</b>        |
| Antennae with 9 distinct segments. . . . .                             | <b>novum</b>         |
| 7. Stem vein dark pilose. . . . .                                      | <b>dicum</b>         |
| Stem vein pale pilose. . . . .   | 8                    |
| 8. Ovipositor flaps only moderately developed. . . . .                 | <b>exigens</b>       |
| Ovipositor flaps well developed (reaching tip of abdomen). . . . .     | <b>dicentum</b>      |

#### KEY TO THE MALES OF PROSIMULIUM

- |   |                      |
|---|----------------------|
| 1. Integument yellow; claspers bilobed with a single spine at apex of each lobe; adminiculum plain. . . . . | <b>fulvum</b>        |
| Integument black; claspers not bilobed; adminiculum modified. . . . .                                       | 2                    |
| 2. Antennae wholly yellow; legs yellow, slightly infuscated apically. . . . .                               | <b>flaviantennus</b> |
| Antennae dark; legs fully infuscated or black. . . . .  | 3                    |
| 3. Adminiculum narrow; side piece greatly modified (fig. 4). . . . .  | <b>pancerastes</b>   |
| Adminiculum broad with conspicuous central keel; side piece plain. . . . .                                  | <b>exigens</b>       |

#### **Prosimulium onychodactylum** Dyar and Shannon

*Prosimulium onychodactylum* Dyar and Shannon, Proc. U. S. National Museum, 69: 4, 1927.

No specimens examined; characters taken from the original description. Integument brownish yellow; legs and antennae yellow; front narrow; claws with large thumb-like projection at base. Male unknown.

*Type locality*.—Long's Peak, Colorado. Type in U. S. National Museum.

#### **Prosimulium novum** Dyar and Shannon

(Figures 9, 10)

*Prosimulium novum* Dyar and Shannon, Proc. U. S. National Museum, 69: 5-6, 1927.

Medium sized, dark species; legs, antennae, integument, black. Distinguished from all other species of the genus by its distinct 9-segmented antennae; genitalia, figures 9-10. Male unknown. Paratype studied.

*Type locality*.—Two Medicine Lake, Montana. Type in U. S. National Museum.

*Distribution*.—Dyar and Shannon record it from Montana, Idaho, California, Washington.

#### **Prosimulium fulvum** Coquillett

(Figures 17, 18)

*Prosimulium fulvum* Coquillett, Proc. U. S. National Museum, 25: 96, 1903.

The bright yellow color serves to distinguish both sexes of this from all others of the genus with the possible exception of *onychodactylum*. It can be readily separated from this latter species by its simple claws; broad front. Genitalia of female, figures 17-18. Female rather common; one male has been found.

*Type locality*.—Bear Paw Mountain, Montana. Type in U. S. National Museum.

*Distribution*.—Mt. Baker, Washington, July 29, 1931 (R. H. Beamer); Mt. Hood, Oregon, July 1, 1927 (E. C. Van Dyke); Strawberry Camp, Grant Co., Oregon (H. A. Scullen); Crater Lake, 7100 ft., Oregon, July 29, 1930; Grand Teton Mountains, Wyoming, September 2, 1941 (J. S. Stanford). Dyar and Shannon also record it from Colorado and Idaho; Twinn from Utah.

### ***Prosimulium unicum* Twinn**

*Prosimulium unicum* Twinn, Can. Ent., 70: 49, 1938.

No specimens at hand; known only by a single female. Characters from the original description would serve to differentiate it: antennae 10-segmented, long and slender; claws simple; body characters and color characters as in *hirtipes*. Male unknown.

*Type locality*.—Morgan, Utah. Type in Canadian National Museum.

### ***Prosimulium flaviantennus* (Stains and Knowlton)**

(Figures 7, 11, 130, 131)

*Eusimulium flaviantennus* Stains and Knowlton, Ann. Ent. Soc. Amer., 33: 79, 1940.

Female with antennae 11-segmented, wholly yellow; thoracic integument black; scutum covered with dense yellow pile; legs yellow, infuscated apically; all coxae wholly black; claws simple. Genitalia, figures 7, 11. Male readily distinguished by its bright yellow antennae and legs, and distinct terminalia (figs. 130–131); otherwise as in *exigens*.

Male of this species heretofore unknown. Because of its close ecological association and close similarity of structure, the writers consider it to be the male of *flaviantennus*.

*Type locality*.—Logan Canyon, Utah. Type in U. S. National Museum.

*Distribution*.—Fort Collins, Colorado, July 5, 1938 (M. T. James); Kanosh Canyon, Utah, May 27, 1939 (Knowlton and F. C. Harmston); Leeds, Utah, June 21, 1941 (Knowlton and F. C. Harmston).

### ***Prosimulium dicum* Dyar and Shannon**

(Figures 14, 15)

*Prosimulium dicum* Dyar and Shannon, Proc. U. S. National Museum, 69: 74, 1927.

Medium sized species; antennae 11-segmented, wholly black; legs black; claws simple; ovipositor flaps well developed; stem vein dark pilose, a character which separates this species from all others of the group. Genitalia, figures 14–15. Male unknown.

*Type locality*.—Hoodsport, Washington.

### ***Prosimulium exigens* Dyar and Shannon**

(Figures 5, 6, 8, 12, 13)

*Prosimulium exigens* Dyar and Shannon, Proc. U. S. National Museum, 69: 10, 1927.  
*Eusimulium hardyi* Stains and Knowlton, Ann. Ent. Soc. Amer., 33: 77–80, 1940.

Difficult to distinguish from the female of the eastern species *hirtipes*. Antennae 11-segmented, black, or with the basal two segments yellow; legs yellow, infuscated apically; ovipositor flaps moderately developed. Male readily distinguished by its broad adminiculum (fig. 6) with a conspicuous central transverse keel; clasper (fig. 5) short with three irregularly placed spines at apex.

*Type locality*.—Moscow, Idaho. Type in U. S. National Museum.

*Distribution*.—Idaho; Mt. Baker, Washington, July 29, 1931 (R. H. Beamer); Mill Creek Canyon, Utah, July 24, 1938 (Knowlton and D. E. Hardy); Kanosh Canyon, Utah, May 27, 1939 (Knowlton and F. C. Harmston); Dyar and Shannon record it from Colorado.

### ***Prosimulium pancerastes* Dyar and Shannon**

(Figures 3, 4)

*Prosimulium pancerastes* Dyar and Shannon, Proc. U. S. National Museum, 69: 10-11, 1927.

Rather large species; adminiculum (fig. 3) narrow, divided on narrow base; clasper short and narrow with 3 spines at apex; side piece greatly modified (fig. 4).

There is some question on the female specimens which Dyar and Shannon associated with the male. They stated, "It is not certain, therefore, that this is the true female of *pancerastes*."

*Type locality*.—Peck, Idaho. Type in U. S. National Museum.

*Distribution*.—Pullman, Washington, April 10, 1898 (C. V. Piper).

### ***Prosimulium dicentum* Dyar and Shannon**

(Figures 16, 24)

*Prosimulium dicentum* Dyar and Shannon, Proc. U. S. National Museum, 69: 7, 1927.

A medium sized species close to *dicum*. Differs in having stem vein pale pilose; anal lobe (fig. 16) more rounded at base. Hearle, (Proc. Ent. Soc. B. C. 29: 7-8, 1932) first described the male from reared material.

*Type locality*.—Truckee, California. Type in U. S. National Museum.

*Distribution*.—Pullman, Washington; Smithfield Canyon, Utah, July 9, 1940 (Harmston and Stains); Scapoose, Oregon, May 21, 1937 (K. Gray and J. Schuh).

### ***Prosimulium pleurale* Malloch**

(Figures 25, 26)

*Prosimulium pleurale* Malloch, U. S. Dept. Agr., Bur. Ent., Tech. Ser. No. 26: 17, 1914.

A species easily distinguished by its dark integument; claws with large thumb-like projection at base and tuft of pile on the anterior sternopleura, lower pteropleura, and upper anterior pteropleura. Genitalia as in figures 25, 26. Male unknown.

*Type locality*.—Kaslo, British Columbia. Type in U. S. National Museum.

*Distribution*.—Pullman, Washington, April 7, 1897 (R. W. Doane).

Genus *Eusimulium* Roubaud*Eusimulium* Roubaud, Compt. Rend. Acad. Sci. Paris, 143: 519, 1906.

The species belonging to this genus have the radius setose over its entire length, radial sector simple, not forked as in *Prosimulium* (exception *osborni*). Calcipala and pedisulcus usually present; claws usually with a large thumb-like projection at base.

Genotype: *Simulium aureum* Fries.

## KEY TO THE FEMALES OF EUSIMULIUM

1. Radial sector with a small branch. . . . . *osborni*  
Radial sector simple. . . . . 2
2. Claws without thumb-like projection at base; calcipala large. . . . . *permutatum*  
Claws with a large thumb-like projection at base; calcipala small or absent. . 3
3. Mesopleura with a distinct tuft of pile (directly behind prothoracic spiracle) *borealis*  
Mesopleura bare. . . . . 4
4. Postnotum with pile on apical margin; scutum and abdomen covered with dense pale pile; two basal segments of antennae yellow. . . . . *aureum*  
Postnotum lacking pile; pile on scutum and abdomen sparse; basal two segments of antennae rarely yellow. . . . . 5
5. Pedisulcus deep and distinct; calcipala small; stem vein pale pilose. . . . . *clarum*  
Pedisulcus shallow or absent; calcipala minute. . . . . 6
6. Pile of stem vein black. . . . . 7  
Pile of stem vein pale. . . . . 8
7. Frons triangular, extremely narrow at base; large species, 3 mm. long (Texas). . . . . *pecuarum*  
Frons of about equal width; size small, 2 mm. long. . . . . *minus*
8. Genital fork arms without ventral tooth, orifice between arms nearly a true circle. . . . . *johannseni*  
Genital fork arms with a distinct ventral tooth. . . . . 9
9. Genital fork arms short and broad, with a large ventral tooth. . . . . *canonicolum*  
Genital fork arms long and slender, with two closely-set small ventral teeth *dacotense*

## KEY TO THE MALES OF EUSIMULIUM

1. Postnotum with small patch of brassy pile on apical margin; adminiculum narrow, contracted and Y-shaped. . . . . *aureum*  
Postnotum without pile; adminiculum broad and membranous. . . . . 2
2. Mesopleura with distinct patch of hair (directly behind prothoracic spiracle); hind basitarsus greatly flattened, wider than tibia. . . . . *borealis*  
Mesopleura without tuft of hair; hind basitarsus not wider than tibia. . . . . 3
3. Clasper with 3 spines at apex; adminiculum broad and triangular. . . . . *obtusum*  
Clasper with 1 spine at apex; adminiculum not triangular. . . . . 4
4. Adminiculum arcuate on dorsum; adminiculum arms with several small teeth. . . . . 5  
Adminiculum truncate or with a depression on dorsum; single tooth or teeth of adminiculum arms large. . . . . 6
5. Adminiculum as wide as long, nearly a true semicircle; clasper tapering to a point at apex. . . . . *dacotense*  
Adminiculum nearly twice as wide as long; clasper obliquely truncate at apex. . . . . *clarum*
6. Adminiculum truncate on dorsum, prongs long divergent (fig. 22); adminiculum arms with 4 or 5 large teeth. . . . . *johannseni*  
Adminiculum with a shallow depression on dorsum; adminiculum arms with only a single large tooth. . . . . 7
7. Adminiculum with small nipple on dorsum; clasper plain. . . . . *pugetense*  
Adminiculum broad, quadrate, without any nipple; clasper with an inner notch at apex. . . . . *quadratus*

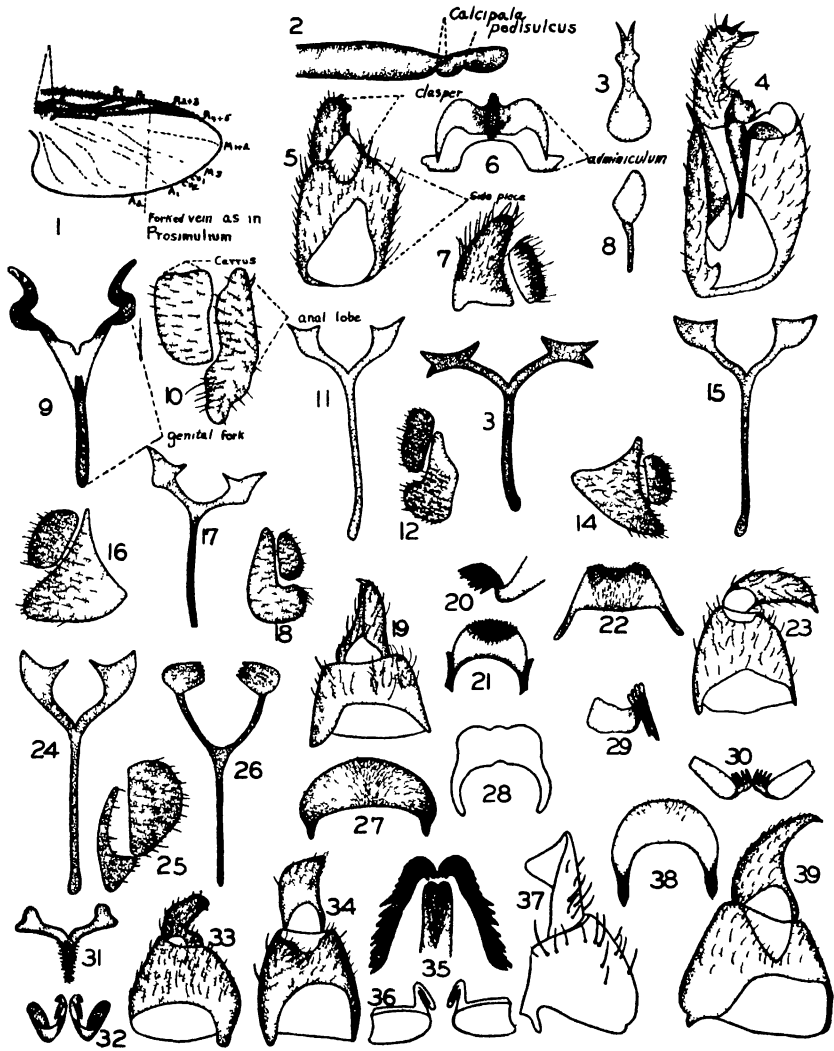


Figure 1, diagrammatic wing (*Prosimulium*); 2, first and second segments of hind tarsus (*Simulium*); 3-4, *P. pancrastes*, ♂ genitalia; 5-6, *P. exigens*, ♂ genitalia; 7, *P. flaviantennatus*, ♀ genitalia; 8, *P. exigens*, ♂; 9-10, *P. novum*, ♀ genitalia; 11, *P. flaviantennatus*, ♀ genitalia; 12-13, *P. exigens*, ♀ genitalia; 14-15, *P. dicum*, ♀ genitalia; 16, *P. discentum*, ♀ genitalia; 17-18, *P. fulvum*, ♀ genitalia; 19-21, *Eusimulium borealis*, ♂ genitalia; 22-23, *E. johannseni*, ♂ genitalia; 24, *P. discentum*, ♀ genitalia; 25-26, *P. pleurale*, ♀ genitalia; 27, *E. clarum*, ♂ genitalia; 28, *E. pugelense*, ♂ genitalia; 29, *E. johannseni*, ♂ genitalia; 30, *E. dacotense*, ♂ genitalia; 31-33, *E. aureum*, ♂ genitalia; 34-35, *E. clarum*, ♂ genitalia; 36-37, *E. pugelense*, ♂ genitalia; 38-39, *E. dacotense*, ♂ genitalia.

**Eusimulium aureum** (Fries)

(Figures 31, 32, 33, 60, 61)

*Simulia aurus* Fries, Monograph Simul. Suec., p. 16, 1824.*Simulium bracteatum* Coquillett, U. S. D. A., Bur. Ent., Tech. Ser. No. 26, 1914.*Eusimulium pilosum* Knowlton and Rowe, Ann. Ent. Soc. Amer., 27: 580-81, 1934.*Eusimulium utahense* Knowlton and Rowe, Ann. Ent. Soc. Amer., 27: 582, 1934.

Both sexes can be distinguished from all others of the genus by the presence of brassy pile on postnotum (postscutellum). Female with bicolored legs; basal 2 segments of antennae yellow; scutum and abdomen covered with dense pale pile. Male wholly black or dark brown; scutum covered with long yellow pile. Genitalia of female, figures 60-61; of male, 31-33.

*Type locality*.—Unknown. Location of type unknown.

*Distribution*.—Logan, Millville, (K.-S.); Kingston, Leeds, Monarch, Soldier Summit (K.-Harmston); Brigham (K.-W.P. Nye); Spanish Fork (D. E. Hardy), in Utah. Boulder, May 18, 1932 (M. T. James), and Rabbit Ear Pass, August 19, 1940 (K.-Nye) in Colorado; Evanston, Wyoming, August 15, 1939 (K.-Harmston); Hood River (Childs) and Antelope Mt., Oregon, June 30, 1931, 6500 ft. (D. K. Frewig); Idaho and California.

**Eusimulium clarum** Dyar and Shannon

(Figures 27, 34, 35, 55, 56)

*Eusimulium clarum* Dyar and Shannon, Proc. U. S. National Museum, 69: 21-22, 1927.

Female dark; pedisulcus deep and distinct; calcipala distinct; stem vein pale pilose; genital fork arm plates broad with a distinct large ventral tooth (fig. 56). Male, clasper short, obliquely truncate (fig. 34), with terminal spine; adminiculum broad, arcuate, considerably longer than wide (fig. 27).

*Type locality*.—Fresno, California. Type in U. S. National Museum.

*Distribution*.—Oroville, California, March 13, 1938 (H. H. Deifer). Nixon, Nevada, June 29, 1927 (E. P. Van Duzee). Logan, Utah, July 22, 1938 (K.-Hardy). Dyar and Shannon also list Montana. Paratype male examined.

**Eusimulium minus** Dyar and Shannon

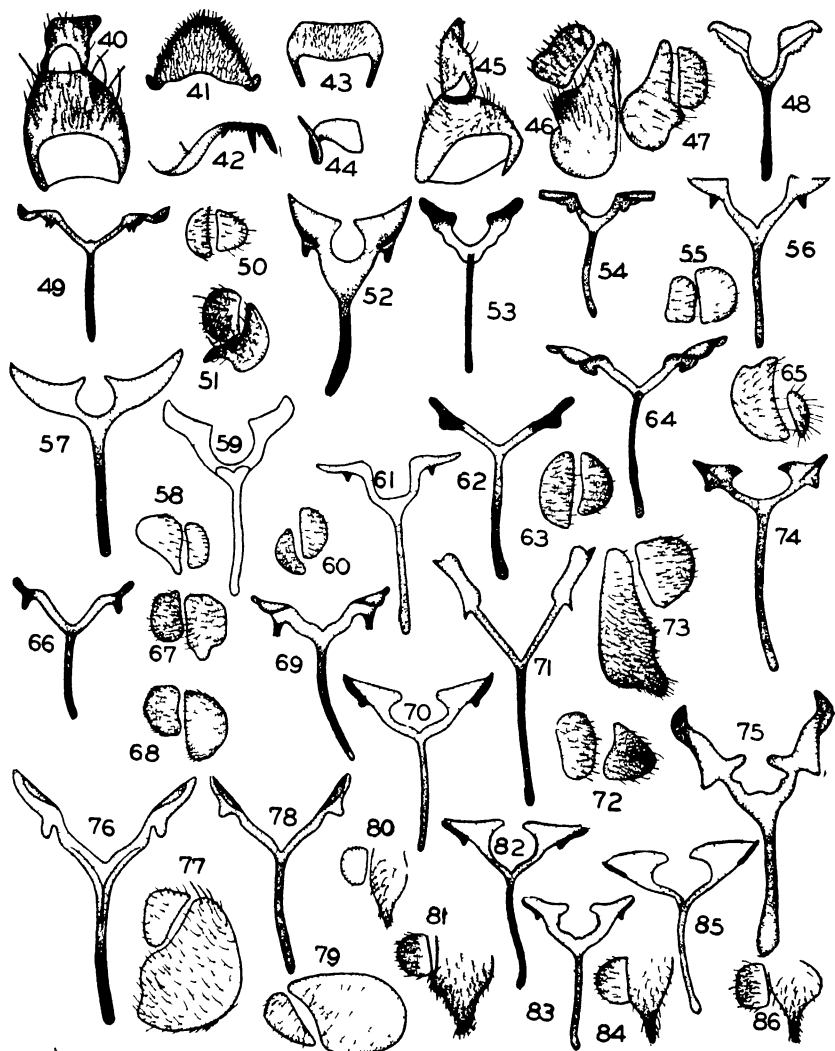
(Figure 54)

*Eusimulium minus* Dyar and Shannon, Proc. U. S. National Museum, 69: 21, 1927.

Close to *canonicolum* and *dacotense*; differs in possessing dark pile on stem vein; genital fork arm plates with a small ventral tooth (fig. 54). Hearle (Proc. Ent. Soc. British Col. 29: 10, 1932) first described the male from reared material.

*Type locality*.—Yosemite, California. Type in U. S. National Museum.

*Distribution*.—Dyar and Shannon record it from Idaho, Montana, Washington, and Wyoming; paratype examined.



Figures 40-45, genitalia of ♂; 46-86, genitalia of ♀. Figures 40-42, *Eusimulium obtusum*; 43-45, *E. quadratus*; 46, *E. pecuarum*; 47-48, *E. mutatum permulatum*; 49-50, *E. dacotense*; 51-52, *E. canonicolum*; 53, *E. pecuarum*; 54, *E. minus*; 55-56, *E. clarum*; 57, *E. johannseni*; 58-59, *E. borealis*; 60-61, *E. aureum*; 62-63, *Simulium venustum*; 64-65, *S. hunteri*; 66-67, *S. occidentale*; 68-69, *S. sayi*; 70, *S. beameri*; 71-72, *S. canadense*; 73-74, *S. vittatum*; 75, *S. virgatum*; 76-77, *S. decorum*; 78-79, *S. archicum*; 80, *S. beameri*; 81-82, *S. bivittatum*; 83-84, *S. griseum*; 85-86, *S. medio-vittatum*.



***Eusimulium mutatum permutatum* Dyar and Shannon**

(Figures 47, 48)

*Eusimulium mutatum permutatum* Dyar and Shannon, Proc. U. S. National Museum, 69: 17-18, 1927.

Readily distinguished by its simple claws; strong calcipala; absence of pedisulcus; dark color of antennae, legs and body. Plates of genital fork large, broad, serrate on ventral surface (fig. 48). Male unknown.

*Type locality*.—Prince Rupert, British Columbia. Type in U. S. National Museum.

*Distribution*.—Mt. Baker, Washington, July 29, 1931 (R. H. Beamer). Recorded from Montana, Idaho, Wyoming and California by Dyar and Shannon.

***Eusimulium borealis* (Malloch)**

(Figures 19, 20, 21, 58, 59)

*Prosimulium borealis* Malloch, Rept. Can. Arctic Exp., 3: 418, 1918.

Distinguished from all others by a tuft of hair on the mesopleural membrane in both sexes. Body grayish black; pedisulcus absent; calcipala small; genitalia of female (after Twinn) figures 58-59; of male, figures 19-21.

*Type locality*.—Woolston Peninsula, Victoria Island. Type in Canadian National Collection.

*Distribution*.—Tooele, Utah, July 7, 1938 (Knowlton-F. C. Harms-ton). Dyar and Shannon also record it from Montana.

***Eusimulium dacotense* Dyar and Shannon**

(Figures 30, 38, 39, 49, 50)

*Eusimulium dacotense* Dyar and Shannon, Proc. U. S. National Museum, 69: 20-21, 1927.

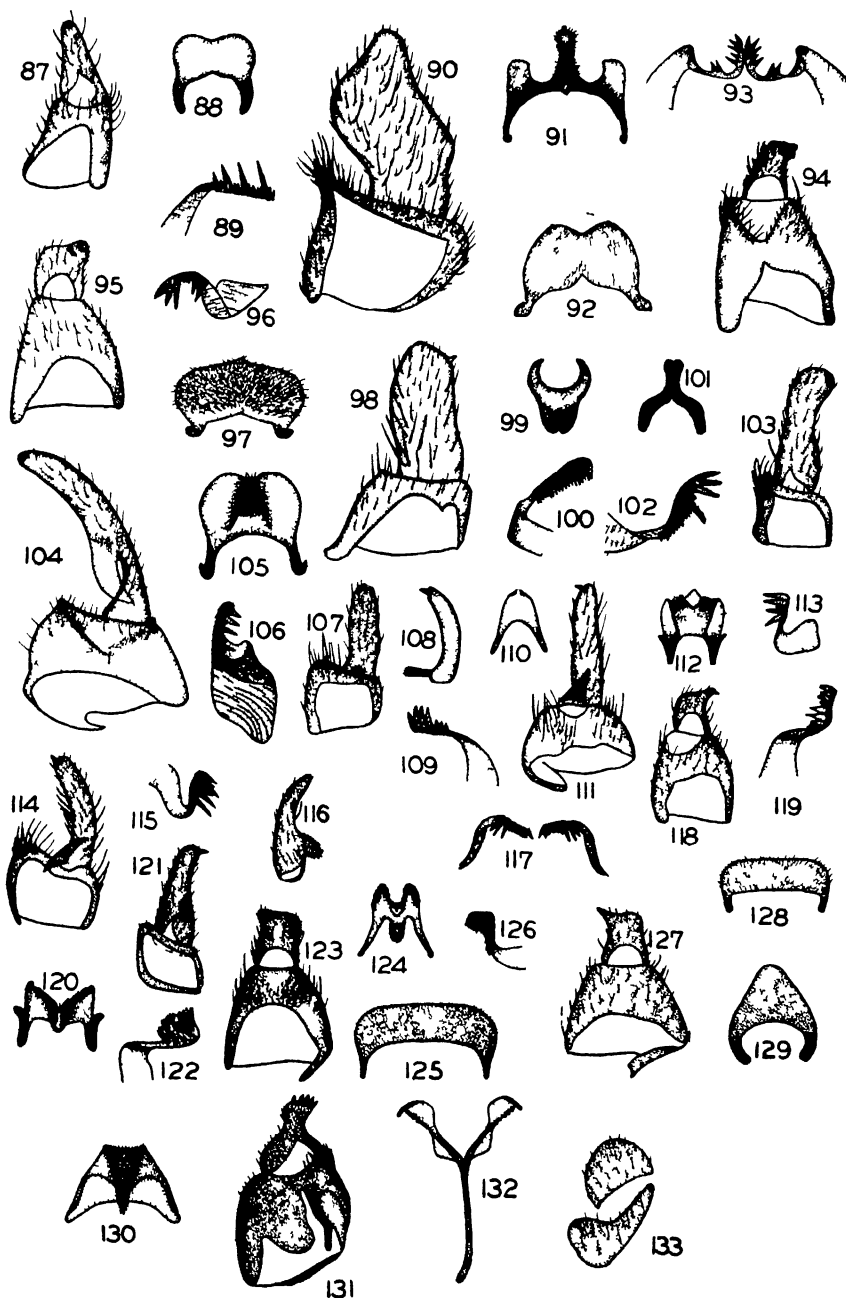
Female small, dark; pedisulcus shallow; calcipala minute; stem vein pale pilose; antennae wholly black; scutum with sparse pale yellow pile. Genitalia, figures 49-50. Male large, dark; pedisulcus and calcipala absent. Readily separated from all other males of the genus by its nearly semicircular adminiculum (fig. 38) and pointed clasper (fig. 39).

*Type locality*.—Brookings, South Dakota. Type in U. S. National Museum.

*Distribution*.—Mink Creek, Idaho, June 25, 1939 (Knowlton); paratype from South Dakota examined.

**EXPLANATION OF PLATE III**

Figures 87-131, genitalia of ♂; 132-133, genitalia of ♀. Figures 87-89, *Simulium occidentale*; 90-91, *S. virgatum*; 92-94, *S. vittatum*; 95-97, *S. kamloopsi*; 98-100, *S. venustum*; 101-103, *S. arcticum*; 104-106, *S. canadense*; 107-110, *S. jacumbae*; 111-113, *S. knowltoni*; 114-115, *S. stonei*; 116, *S. vandalicum*; 117, *S. mediovittatum*; 118-119, *S. griseum*; 120, *S. stonei*; 121, *S. vandalicum*; 122-123, *S. bivittatum*; 124, *S. vandalicum*; 125, *S. bivittatum*; 126, *S. vandalicum*; 127, *S. mediovittatum*; 128, *S. griseum*; 129, *S. mediovittatum*; 130-131, *Prosimulium flaviantennatus*; 132-133, *Eusimulium osborni*.



**Eusimulium canonicolum** Dyar and Shannon

(Figures 51, 52)

*Eusimulium canonicolum* Dyar and Shannon, Proc. U. S. Nat. Mus., 69: 22, 1927.

A small dark species; antennae wholly black; claws with large thumb-like projection at base; stem vein pale pilose; genital fork (fig. 52) with broad thick arms and a distinct large ventral tooth. Male unknown.

*Type locality*.—Yellowstone Canyon, Wyoming. Type in U. S. National Museum.

*Distribution*.—Dyar and Shannon record it from California, Colorado, Idaho and Wyoming.

**Eusimulium pecuarum** (Riley)

(Figures 46, 53)

*Simulium pecuarum* Riley, Rept. U. S. Dept. Agr. 1886, p. 512.

Large dark species about 3 mm. long; antennae black, basal 2 segments brown; frons triangular, extremely narrow at base; claws with large thumb-like projection at base; scutum with 3 indistinct stripes when viewed from front; calcipala small; pedisulcus absent; legs brownish. Genitalia, figures 46, 53. The male was redescribed and figured by Bradley (Proc. Ent. Soc. Wash. 37: 63-64, 1935).

*Type locality*.—Somerset Landing, Louisiana. Type in U. S. National Museum.

*Distribution*.—Lufkin, Texas, January 17, 1941 (H. J. Reinhard).

**Eusimulium johannseni** (Hart)

(Figures 22, 23, 29, 57)

*Simulium johannseni* Hart, 27th Ill. St. Ent. Rept., p. 32, 1912.

Female with stem vein pale pilose; calcipala minute; pedisulcus shallow; antennae black; scutum with three indistinct vittae, clothed with pale pile; genital fork arms horn-like without ventral tooth; genitalia, figure 57. Male with integument and antennae black; legs paler in color; scutum with sparse pale pile; adminiculum truncate, with a small triangular notch on dorsum (fig. 22), prongs divergent; adminiculum arms with four or five large teeth (fig. 29).

*Type locality*.—Havana, Illinois. Type in Illinois Natural History Survey collection.

*Distribution*.—Dyar and Shannon also list Idaho. Paratypes examined.

**Eusimulium obtusum** Dyar and Shannon

(Figures 40, 41, 42)

*Eusimulium obtusum* Dyar and Shannon, U. S. National Museum Proc., 69: 15, 1927.

One cotype male at hand is mounted on a slide in balsam with only the terminalia in good condition. Side piece a little longer than broad; clasper short (fig. 40), truncate with 3 terminal spines at apex; adminiculum broad and triangular (fig. 41); adminiculum arms each with 2 large teeth (fig. 42). Female unknown.

*Type locality*.—Redlands, California. Type in U. S. National Museum.

**Eusimulium pugetense** Dyar and Shannon

(Figures 28, 36, 37)

*Eusimulium pugetense* Dyar and Shannon, Proc. U. S. National Museum, 69: 23, 1927.*Eusimulium quebecense* Twinn, Can. Journ. Res., 14: 117-118, 1936.

The following description (except figure numbers) is from Twinn's *quebecense*, a synonym of *pugetense*. Female near *aureum*, differs in having antennae entirely black; postnotum devoid of brassy pile, pilosity more sparse. Male characterized by yellow pilosity on scutum; integument, antennae, pubescence, halteres, stem vein and plural tuft black; adminiculum with small nipple in a median depression on the dorsum (fig. 28); adminiculum arms with a single large tooth (fig. 36). Genitalia figures are redrawn from Twinn.

*Type locality*.—Seattle, Washington. Type male in U. S. National Museum.

**Eusimulium quadratus** n. sp.

(Figures 43, 44, 45)

*Male*.—Length 1.9 mm.; wing 2.3 mm. With characters of the genus. Radius setose its entire length, radial sector simple. Head black; clypeus pale yellow pilose. Antennae 11-segmented, black. Thorax black; scutum velvety black, covered with sparse pale yellow pile; scutellum with long pale pile; pleurites dark. Legs brownish black, covered with sparse pale yellow pile; hind basitarsus about the same width as the tibia; pedisulcus and calcipala present. Halteres light brown; stem vein pale pilose. Abdomen black, covered with sparse pale pile, basal fringe pale. Genitalia: adminiculum (fig. 43) broad and quadrate; clasper (fig. 45) with an inner notch at apex and a single spine; adminiculum arms (fig. 44) with a single large tooth.

*Taxonomy*.—*Eusimulium quadratus* is near *pugetense* but differs in having a broader adminiculum and not possessing a nipple on dorsum. This may prove to be the undescribed male of *canonicolum*.

*Holotype*.—Male. Logan Canyon, Utah, June 28, 1940 (Knowlton).

*Paratype*: Male. Same data as holotype.

**Eusimulium osborni** n. sp.

(Figures 132, 133)

*Female*.—Length 2.2 mm., of wing 2.5 mm. Head black; clypeus grayish pruinose, frons grayish pruinose, narrow at base. Antennae wholly black with the second segment enlarged. Thorax black; scutum black, covered with sparse pale pile; scutellum dark and bare. Legs black; pedisulcus present, calcipala shallow; claws with large thumb-like projection. Wings dark; stem vein dark pilose; radial sector with a short fork; halteres dark brown. Genitalia as in figures 132 and 133.

*Taxonomy*.—*E. osborni* differs from all other *Eusimulium* with the exception of *lascivum* Twinn in having a small branch on the radial sector. It differs from *lascivum* Twinn in possessing a large thumb-like projection at base of claws and in genitalia characters.

*Holotype*.—Female, Brightman Flat, Tuolumne County, California, June, 1941 (R. T. Orr), on grouse. *Paratypes*.—Females with same data.

Genus *Simulium* Latreille

(Figure 2)

*Simulium* Latreille, Hist. Nat. Ins. et. Crust., 3: 426, 1802.

Radial sector simple, bare from the stem vein to the base of the radial sector; calcpala and pedisulcus always present; usually silvery pilosity on fore tibia; claws seldom possessing a large thumb-like projection at base; small basal tooth present or absent.

Genotype: *Culex replans* Linnaeus.

## KEY TO THE FEMALES OF SIMULIUM

1. Legs wholly black; claws with large thumb-like projection at base. . . . . **occidentale**  
 Legs bicolored; claws without large thumb-like projection at base (may have small basal tooth) . . . . . 2
2. Fore coxae yellow; frons shining black or grayish pruinose . . . . . 3  
 Fore coxae black; frons always grayish pruinose . . . . . 4
3. Claws with small basal tooth<sup>4</sup>. . . . . 5  
 Claws simple, without such a tooth . . . . . 6
4. Claws plain, without small basal tooth; five dark vittae on scutum; genital fork arms ending in large quadrangular plates . . . . . **vittatum**  
 Claws with small basal tooth; scutum with 3 indistinct vittae; genital fork arms ending in small plates with a distinct ventral tooth . . . . . **sayi**
5. Frons grayish pruinose; stem vein always dark pilose . . . . . 7  
 Frons shining black; stem vein pale pilose or dark pilose . . . . . 8
6. Antennae black, with only 2 basal segments yellow; fore tarsal segments largely flattened; anal lobe rounded, not produced ventrally . . . . . 9  
 Antennae wholly yellow or infuscated toward apex; fore tarsal segments not flattened; anal lobe produced to a point ventrally . . . . . 10
7. Antennae brown with 2 basal segments yellow; scutum with an orange tinge; species 2.5 mm. long; genitalia fig. 75 . . . . . **virgatum**  
 Antennae black with two basal segments brown; scutum wholly black; species about 2 mm. long; genitalia figs. 71-72 . . . . . **canadense**
8. Mesonotum with 3 narrow pollinose vittae; pile of stem vein dark; anal lobe small and narrow . . . . . **hunteri**  
 Mesonotum without vittae, only 2 silvery pruinose areas at front of scutum; pile of stem vein pale; anal lobe large and broad . . . . . **arcticum**
9. Frons grayish pruinose; anal lobe at least 3 times larger than cercus . . . . . **decorum**  
 Frons shining black; anal lobe only slightly larger than cercus . . . . . **venustum**
10. Scutum with a single distinct central stripe or with 2 silvery white stripes . . 11  
 Scutum plain, without distinct stripes . . . . . 12
11. Scutum with 2 broad silvery white stripes . . . . . **bivittatum**  
 Scutum with a single distinct central stripe . . . . . 13
12. Antennae wholly yellow; legs yellow except fore tarsi and apical segment of middle and hind tarsi (rare) . . . . . **notatum**  
 Antennae infuscated apically; legs yellow except apex of first and second, third, fourth and fifth segments of middle and hind tarsi; fore tarsi black . . . . . **griseum**
13. Scutum yellow with a central dark brown strip; antennae wholly yellow, . . . . . **mediovittatum**  
 Scutum opaque black, with a distinct central velvety black stripe; antennae infuscated apically . . . . . **beameri**

## KEY TO THE MALES OF THE GENUS SIMULIUM

1. Clasper at least one-fourth longer than side piece; adminiculum contracted, solid . . . . . 2  
 Clasper shorter than or as long as side piece; adminiculum broad and membranous . . . . . 3

<sup>4</sup>The small basal tooth usually can be seen only under high magnification. To see this character, place the claw on a slide in a small amount of glycerine; place a small cover glass over glycerine and press until full side view of claw is visible.

2. Clasper with an inner lateral projection at base (plainly seen when clasper is turned on side); small species, usually less than 2 mm. long. . . . . 4  
Clasper plain, without such projection; species usually more than 2 mm. long. . . . . 5
3. Clasper truncate at apex, about half as long as side piece; legs bicolored. . . 6  
Clasper tapering to a point at apex, about as long as side piece; legs wholly black. . . . . **occidentale**
4. Lateral projection at base of clasper sharply pointed; prongs of adminiculum with lateral projections. . . . . 7  
Lateral projection at base of clasper rounded, spinose or long and serrated on apex; prongs of adminiculum plain, without lateral projections. . . . . 8  
Ribbon-like structure lying parallel to clasper (fig. 104), adminiculum arcuate, with small notch on dorsum. . . . . **canadense**
5. Clasper greatly flattened and irregularly curved, about twice as long as wide; adminiculum with shoulders projecting (fig. 91). . . . . **virgatum**  
Clasper not so flattened nor irregularly curved, approximately 3 times as long as wide; adminiculum without definite shoulders. . . . . 9
6. Clasper with a single terminal spine at apex or none; middle femora and tibia wholly yellow or only slightly infuscated. . . . . 10  
Clasper with 2 or more spines at apex; middle femora and tibia at least one-half black. . . . . 11
7. Adminiculum with a central cone on dorsum extending well above shoulders, **knowltoni**  
Adminiculum with a trough-like incision on dorsum. . . . . **stonei**
8. Projection at base of clasper narrow, fully twice as long as wide, serrated only on apex, adminiculum narrow, conical on dorsum (fig. 110). . . **jacumbae**  
Projection at base of clasper round, spinose, about as long as wide; adminiculum with deep dorsal incision and ventral keel (fig. 124), **vandalicum**
9. Adminiculum Y-shaped, base narrow; adminiculum arms with large teeth (fig. 102). . . . . **arcticum**  
Adminiculum somewhat tooth-shaped with a divided base or broad and arcuate; adminiculum arms with small teeth. . . . . 12
10. Adminiculum rectangular, twice as wide as long, a little curved on dorsum. . . 13  
Adminiculum narrow, triangular, about as wide as long. . . . . **mediovittatum**
11. Clasper truncate, with two spines at apex; scutum with 2 conspicuous silvery stripes extending half of its length. . . . . **kamloopsi**  
Clasper tapers toward apex, with 3 terminal spines; scutum with only 2 small indistinct anterior pollinose stripes on dorsum. . . . . **vittatum**
12. Adminiculum arcuate, with small notch on dorsum; clasper narrow, twice length of side piece. . . . . **canadense**  
Adminiculum narrow and tooth-shaped; clasper broad, about 1.5 length of side piece. . . . . **venustum**
13. Small species about 1.5 mm. long; scutum with a greenish metallic tinge; apex of clasper obliquely truncate. . . . . **griseum**  
Species about 2 mm. long; scutum velvety black, with 2 anterior pollinose patches; clasper truncate at apex. . . . . **bivittatum**

### **Simulium occidentale** Townsend

(Figures 66, 67, 87, 88, 89)

*Simulium occidentale* Townsend, Psyche, 6: 107, 1891.

A medium sized dark species in both sexes. Females readily distinguished by presence of a large thumb-like projection at base of claws; legs and antennae wholly black or dark brown. Male with legs, antennae, integument and halteres wholly dark brown or black. Genitalia of female, figures 66-67; of male, figures 87-89.

*Type locality*.—Rio Grande Valley, New Mexico. Location of type unknown.

**Distribution.**—The writers have examined material of this species from Utah, Idaho, California, Kansas, South Dakota, New Mexico and Colorado; Dyar and Shannon also recorded it from Texas.

***Simulium virgatum* Coquillett**

(Figures 75, 90, 91)

*Simulium virgatum* Coquillett, Proc. U. S. National Museum, 25: 87, 1903.

A rather large, light colored species in both sexes. Female with frons grayish pilose; antennae brown, basal two segments yellow; fore coxae yellow; claws with small basal tooth; mesonotum with two diagonal stripes, space between stripes brownish-orange; arms of genital fork with large spear-shaped endings (fig. 75). Male can be distinguished by its large, flattened and irregularly curved claspers (fig. 90).

**Type locality.**—Las Vegas, Hot Springs, New Mexico. Type in U. S. National Museum.

**Distribution.**—Nephi, Utah, June 16, and Mt. Timpanogos, Utah, August 17, 1941 (Knowlton-F. C. Harmston); Pine, Oregon, 7-22-92; Texas. Dyar and Shannon also record it from California, New Mexico, South Dakota.

***Simulium vittatum* Zetterstedt**

(Figures 73, 74, 92, 93, 94)

*Simulium vittatum* Zetterstedt, Ins. Lappon. Dipt., 1835, p. 803.

Probably the most cosmopolitan species in the entire family. Females large, gray colored; legs bicolored, basal 2 antennal segments yellow, remainder dark; mesonotum with 5 dark stripes; claws simple; frons grayish pruinose; fore coxae black. Male rather variable, resembles several species externally; internal terminalia very characteristic. Female genitalia, figures 73-74; male, figures 92-94.

**Type locality.**—Probably Lapland. Type presumably in University of Lund, Sweden.

**Distribution.**—Material examined from Utah, Idaho, Colorado, Nevada, Wyoming, Washington, Oregon, Montana, Nebraska, Kansas, South Dakota, California and New Mexico.

***Simulium kamloopsi* Hearle**

(Figures 95, 96, 97)

*Simulium kamloopsi* Hearle, Proc. Ent. Soc. B. C., No. 29, 12-13, 1932.

*Simulium hearlei* Twinn, Can. Ent., 70: 50, 1938.

A medium small, dark colored species with bicolored legs. Distinguished readily by two conspicuous silvery pollinose stripes on the dorsum of the mesonotum; fore tibiae with conspicuous silvery pilosity. Male genitalia as in figures 95-97. Female unknown.

**Type locality.**—Kamloops, B. C. Type in Canadian National Museum.

**Distribution.**—Ft. Duchesne, Midvale, Logan, Juab, Granite and Bluff in Utah; Buhl, and Arimo, Idaho, August, 1939 (Knowlton-F. C. Harmston).

**Simulium venustum** Say

(Figures 62, 63, 98, 99, 100)

*Simulium venustum* Say, Jour. Acad. Sci. Phila., 3: 28, 1829.

Female close to *arcticum*; differs in having stem vein usually dark pilose and no basal tooth on claws; genitalia figures 62-63. Male resembles a number of other species externally, but differs markedly in genitalia (figs. 98-100).

*Type locality*.—Shippingsport, Ohio. Location of type unknown.

*Distribution*.—Utah, Idaho, Colorado, California, Washington, Montana, Wyoming. Dyar and Shannon also record it from Texas.

**Simulium decorum** Walker

(Figures 76, 77)

*Simulium decorum* Walker, Cat. Brit. Mus. Dipt., Vol. 1, p. 112, 1848.

Female large; fore coxae yellow; frons shining black; antennae black, basal two segments yellow; stem vein pale pilose; claws simple. Genitalia, figures 76-77. No males at hand.

*Type locality*.—Martin Fall, Ontario. Type in British Museum.

*Distribution*.—Boulder, Colorado (T. D. A. Cockerell).

**Simulium sayi** Dyar and Shannon

(Figures 68, 69)

*Simulium sayi* Dyar and Shannon, U. S. National Museum Proc., 69: 40-41, 1927.

A large dark colored species about 3.2 mm. long; characterized by prominent yellow markings on hind basitarsi; frons grayish pruinose; fore coxae black; antennae black; pile on stem vein dark; claws with small basal tooth; scutum with three indistinct vittae; genitalia as in figures 68-69. Male unknown.

*Type locality*.—Virginia Dale, Colorado. Type in U. S. National Museum.

*Distribution*.—Logan Canyon, Utah, October 10, 1938 (F. C. Harmston). Roosevelt, Utah, July 7, 1940, and Moab, Utah, (Knowlton-Harmston); Spearfish, South Dakota, July 28, 1924, (Hull, Det. A. Stone); Colorado.

**Simulium hunteri** Malloch

(Figures 64, 65)

*Simulium hunteri* Malloch, U. S. Dept. Agr., Bur. Ent., Ser. 26: 59, 1914.

A rather large species distinguished by shining black frons; fore coxae yellow; distinct sharp basal tooth on claws; stem vein dark pilose; mesonotum with three narrow vittae; antennae black, basal two segments yellow. Genitalia as in figures 64-65. Male unknown.

*Type locality*.—Virginia Dale, Colorado. Type in U. S. National Museum.

*Distribution*.—Logan Canyon, Utah, October 10, 1938 (Harmston); Spearfish, South Dakota (Hull, Det. A. Stone); Estes Park, Colorado, August 8, 1925 (H. C. Severin, Det. Stone); Grand Teton Mountains, Wyoming, September 2, 1941 (J. S. Stanford). Dyar and Shannon also record it from New Mexico.



***Simulium arcticum* Malloch**

(Figures 78, 79, 101, 102, 103)

*Simulium arcticum* Malloch, U. S. Dept. Agr., Bur. Ent. Tech. Ser. 26: 37, 1914.*Simulium brevicercum* Knowlton and Rowe, Ann. Ent. Soc. Amer., 27: 583, 1934.*Simulium nigrescens* Knowlton and Rowe, Ann. Ent. Soc. Amer., 27: 583, 1934.*Simulium corbis* Twinn, Can. Jour. Res., 14: 147-148, 1936.

Female, medium to large; fore coxae yellow; frons shining black; antennae black, basal two segments yellow; scutum with two anterior silvery pollinose patches; stem vein pale pilose; claws with small basal teeth; genitalia, figures 78-79. Male readily distinguished by its long simple clasper (fig. 103) and inverted Y-shaped adminiculum (fig. 101).

*Type locality*.—Kaslo, British Columbia. Type in U. S. National Museum.

*Distribution*.—Material examined from California, Utah, Washington, Idaho, Colorado. Dyar and Shannon also list it from Montana, Nevada, Oregon and Wyoming.

***Simulium canadense* Hearle**

(Figures 71, 104, 105, 106)

*Simulium virgatum canadense* Hearle, Proc. B. C. Ent. Soc., 29: 14-15, 1932.*Simulium fraternum* Twinn, Can. Ent., 70: 53-54, 1938.

Female fairly large, dark colored, near *virgatum*; differs in being a little smaller in size; antennae black, basal two segments brown; genital fork arms (fig. 71) ending in small rectangular plates, with distinct ventral tooth and a small apical tooth. Male having long narrow clasper (fig. 104) with narrow ribbon-like projection pointed at base; adminiculum (fig. 105) arcuate, with a small central notch on dorsum.

*Type locality*.—Kamloops, British Columbia. Type in Canadian National Collection.

*Distribution*.—Farmington, Utah, April 9, 1934 (Knowlton-C. F. Smith).

***Simulium jacumbae* Dyar and Shannon**

(Figures 107, 108, 109, 110)

*Simulium jacumbae* Dyar and Shannon, Proc. U. S. National Museum, 69: 44-45, 1927.

Small, about 1.9 mm. long; belongs with the group of species having the inner lateral projection at base of clasper (fig. 108). Readily distinguished from other members of the group by the narrow adminiculum, conical on dorsum (fig. 110).

*Type locality*.—Jacumba Springs, California. Type in U. S. National Museum.

*Distribution*.—Cowley, Colorado, September 2, 1939 (M. T. James); Little Lake, California, July 25, 1940 (D. E. Hardy); Santa Clara, Utah, July 19, 1941 (Harmston-Knowlton).

**Simulium knowltoni** Twinn

(Figures 111, 112, 113)

*Simulium knowltoni* Twinn, Can. Ent., 70: 53, 1938.

Small, about 2.2 mm. long; belongs in the group having a lateral projection on inner side at base of clasper; differing from all others except *stonei* in having this projection at base of clasper sharply pointed (fig. 111). Readily distinguished from *stonei* in possessing a central cone-like projection on dorsum of adminiculum (fig. 112). Female unknown. This may prove to be the undescribed male of *sayi* D.-S.

*Type locality*.—Logan, Utah. Type in Canadian National Museum.

*Distribution*.—Logan, Utah; Monticello, Utah, May 13, 1939 (Knowlton-F. C. Harmston); California (A. Stone).

**Simulium stonei** n. sp.

(Figures 114, 115, 120)

*Male*.—Length 1.9 mm.; wing 2.2 mm. With characters of the genus; radius bare, devoid of setae; radial sector simple. Head black; clypeus silvery pruinose; antennae wholly black and 11-segmented. Thorax black; scutum and scutellum black with sparse yellow pile; pleurites silvery pruinose. Legs black, sometimes infuscated. Wings darkened at base, stem vein black pilose; halteres pale yellow, base merging into black. Abdomen black; apical segments slightly silvery pruinose; basal fringe brown. Genitalia: adminiculum (fig. 120) with branched prongs, a trough-like incision on dorsum; adminiculum arms (fig. 115) with several large teeth; clasper (fig. 114) with a sharply pointed non-spinose projection at base. Female unknown.

*Taxonomy*.—*Simulium stonei* is near *knowltoni*. It differs distinctly in having a trough-like incision on dorsum of adminiculum (fig. 120).

*Holotype*.—Male, Logan, Utah, September 16, 1939 (Knowlton-Stains). *Paratypes*.—Males, Logan Canyon, Utah, October 3, 1937 (D. E. Hardy); Pocatello, Idaho, September 20, 1939 (Harmston).

**Simulium vandalicum** Dyar and Shannon

(Figures 116, 121, 124, 126)

*Simulium vandalicum* Dyar and Shannon, U. S. National Museum Proc., 69: 44, 1927.

*Simulium turmale* Twinn, Can. Ent., 70: 51, 1938.

Small dark species about 1.9 mm. long. Belongs in group with basal projection on clasper (fig. 116) rounded, about as long as wide and heavily spinose; adminiculum with a deep dorsal incision, ventral keel below incision (fig. 124); prongs of adminiculum divergent without any lateral projections. Dyar and Shannon state that the female is indistinguishable from *venustum*.

*Type locality*.—Fallen Leaf, California. Type in U. S. National Museum.

*Taxonomy*.—Upon the request of the writers, Dr. A. Stone compared the holotype of *S. twinni* S.-K. with *S. vandalicum* D.-S. He stated, "It does not seem possible to distinguish *Simulium twinni* from *S. vandalicum*, save that the terminalia of *twinni* are slightly smaller. I can see no significant differences. The dorsal incision is not quite so deep as in the holotype of *twinni*, but the difference is very slight." Because of the above information, the writers are tentatively considering *twinni* (Ann. Ent. Soc. Amer. 33: 77–80, 1940) a variety of *vandalicum*. Twinn records *turmale* Tw. from Utah; this appears to be a synonym of *vandalicum*.

### ***Simulium bivittatum* Malloch**

(Figures 81, 82, 122, 123, 125)

*Simulium bivittatum* Malloch, U. S. Dept. Agr., Bur. Ent. Tech. Ser. 26: 31, 1914.

*Simulium idahoense* Twinn, Can. Ent., 70: 50–51, 1938.

Female small, pale colored, about 1.7 mm. long; can readily be separated from other species by two broad silvery pollinose stripes on the mesonotum; antennae infuscated. Genitalia, figures 81–82. Male closely resembles *mediovittatum* externally; differs internally in having adminiculum twice as wide as long (fig. 125) and only slightly arcuate on dorsum.

*Type locality*.—East Las Vegas, New Mexico. Type in U. S. National Museum.

*Distribution*.—Also includes Utah, Idaho, Colorado, South Dakota.

*Taxonomy*.—Heretofore, the male of *bivittatum* has been unknown. The type locality and data of *idahoense* are the same as for a long series of *bivittatum* females at hand; also on three different occasions males of *idahoense* and females of *bivittatum* have been taken together. Twinn, in his original description, suggested his species might be the male to *bivittatum*. The writers consider this to be the case.

### ***Simulium notatum* Adams**

*Simulium notatum* Adams, Kan. University Sci. Bul., 2: 434, 1904.

A small pale yellow species close to *griseum*; female distinguished from *griseum* by legs being entirely yellow except fore tarsi and apical segments of middle and hind tarsi; antennae wholly yellow.

*Type locality*.—Williams Fork, Arizona. Type in University of Kansas insect collection.

*Distribution*.—Dyar and Shannon record it from New Mexico, Texas. Cotype female examined.

### ***Simulium griseum* Coquillett**

(Figures 83, 84, 118, 119, 128)

*Simulium griseum* Coquillett, U. S. Dept. Agr. Bul. 10, n. ser., p. 69, 1898.

Female pale colored, about 1.7 mm. long; legs largely yellow; antennae infuscated apically; mesonotum plain or with faintly distinguishable median stripe. Genitalia, figures 83–84. Male with metallic greenish mesonotum, sometimes a rather distinct median stripe. Genitalia, figures 118–119, 128.

*Type locality*.—Colorado. Type in U. S. National Museum.

*Distribution*.—Ft. Collins, Colorado, June 16, 1905; Musselshell, Montana, July 11, 1917; Strawberry Valley, Utah, June 14, 1940 (Knowlton); Manila, Utah, September 5, 1939 (K.-Harmston); Cascade Springs, South Dakota, July 30, 1935 (H. C. Severin). Dyar and Shannon also record it from New Mexico.

### ***Simulium mediovittatum* Knab**

(Figures 85, 86, 117, 127, 129)

*Simulium mediovittatum* Knab, Ins. Mens., 3: 77, 1916.

*Simulium venator* Dyar and Shannon, U. S. National Museum Proc., 69: 36, 1927.

Female mesonotum yellow pollinose with a distinct brown median stripe; antennae wholly yellow; fore tarsi largely black; remainder of legs mostly yellow. Genitalia, figures 85–86. Male with a wide median yellow stripe on posterior part of mesonotum or with scutum mostly black; antennae infuscated; adminiculum about as long as wide, conical on dorsum (figs. 117, 127, 129).

*Type locality*.—Arlington, Texas. Type in U. S. National Museum.

*Distribution*.—Lewiston, Utah, on nose of horse suffering from equine encephalomyelitis (J. A. Rowe); Riverdale, Idaho, August 22, 1934 (Knowlton-C. F. Smith); Weiser, Idaho; Meacham and Dixie, Oregon, September 2, 1940 (F. C. Harmston); 10 miles east of Huntington, Oregon, July 22, 1936 (H. A. Scullen). Dyar and Shannon record it also from Nevada, California and Montana.

### ***Simulium trivittatum* Malloch**

*Simulium trivittatum* Malloch, U. S. Dept. Agr., Bur. Ent., Tech Ser. 26: 30, 1914.

No specimens examined; female close to *bivittatum*. Separated from this species by three dark brown vittae on scutum; genitalia characters showing distinct differences (Dyar and Shannon, Proc. U. S. National Museum 69, 1927, plate 6, fig. 78). Recorded from Texas by Dyar and Shannon.

### ***Simulium beameri* n. sp.**

(Figures 70, 80)

*Female*.—Length 1.3 mm.; wing 1.6 mm. Head black; clypeus grayish pruinose; frons grayish pruinose with a black ground color. Antennae yellow, apical two-thirds infuscated. Thorax black; scutum black, edges merging into yellow, a black velvety stripe extending down its middle, scutellum yellow, pleurites mostly black. Legs bicolored. Wings with all veins pale yellow, stem vein pale pilose; halteres pale yellow. Abdomen yellowish with the usual black dots on dorsum. Genitalia as in figures 70 and 80.

*Male*.—Length 1.3 mm.; wing 1.7 mm. Head black; antennae yellow, infuscated apically; clypeus grayish pruinose. Thorax velvety black; two small grayish pruinose patches on fore part and lateral and apical edges of scutum; scutellum black; pleurites grayish pruinose. Wings with stem vein pale pilose; halteres yellow. Abdomen black; apical segments of abdomen with grayish pruinose areas.

Genitalia indistinguishable from those of *mediovittatum* (cf. figures 117, 127, 129).

*Taxonomy*.—*S. beameri* is near *mediovittatum* but differs in having a dark to black scutum with a velvety black median stripe, rather than a pale scutum with brown stripes; antennae infuscated instead of entirely yellow.

*Holotype*.—Female, allotype male, Lone Pine, California, July 28, 1940 (R. H. Beamer). *Paratype*.—Males and females, Mammoth Lakes, California, July 29, 1940 (R. H. Beamer). Others same data as holotype. Types in the University of Kansas insect collection.

### *Simulium piperi* Dyar and Shannon

*Simulium piperi* Dyar and Shannon, Proc. U. S. National Museum, 69: 38-39, 1927.

No specimens at hand. Described from a single male taken at Seattle, Washington, by Dyar and Shannon; "Entirely black, including legs; anterior half of mesonotum faintly and diffusely pale pollinose; thoracic pile brassy; scutellum fringed with black hairs; stem vein black pilose."

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THE ELEMENTS OF STATISTICS, by ELMER B. MODE. Pages xvi and 378. 1941. 6¼x9¼ inches, linen. Published by PRENTICE-HALL, INC., 70 Fifth Avenue, New York, N. Y. Price \$3.50.

The author, who is Professor of Mathematics at Boston University, has designed this text for use in a course in general introductory statistics. It is directed at no particular field of interest. In fact students of economics, psychology, education, biology, and other disciplines will find discussed here the basic principles and practices common to all fields. The chapters are largely devoted to expositions of the methods of descriptive statistics for large samples. After introductory chapters dealing with methods of computation, charts, diagrams, graphs, and frequency distributions, the author discusses the various useful positional averages, including index numbers, the common measures of dispersion, and the statistics of curve form. These topics are followed by discussions of the normal frequency curve, curve fitting, and correlation. The binomial distribution, which actually occupies a central position in the development of statistical theory, is given an apparently unimportant place in the next to the last chapter. The Poisson distribution is treated on a single page. To students of economic field entomology, who use this distribution frequently, this may be regarded as a shortcoming. The final chapter deals with the sampling errors of common statistics. This should serve as a transition to a study of statistical tests of significance of differences which are not treated in this text.

A set of mathematical tables commonly needed in statistical work supplements the text. A short list of books and journals, classified according to field, will help to introduce the student to other expositions of statistical methods.

—E. L. GREEN.

# REVISION OF THE GENUS *COPHURA* OSTEN SACKEN (Diptera: Asilidae)

A. EARL PRITCHARD,

Division of Entomology and Economic Zoology,  
University of Minnesota

The exact limitations of *Cophura* have been a subject of speculation among American workers since Osten Sacken (1886) described the genus. Various writers have added species to the genus with the understanding that it is heterogeneous, including diverse forms. No treatise of relationships has been attempted, probably because of the difficulty of getting together described species. Most of these species are known in literature only by the original descriptions, and limited special collecting in the southwestern States has given the impression that they are rare. Largely due to the success of rather recent collecting, the author has been able to accumulate nearly all the known species and so enabled to make a comprehensive revision.

Loew in 1872, erected the genus *Blax* for his species *bella* from Texas. *Blax* was later found to be preoccupied; *Blacodes* Loew (1874) and *Loewiella* Williston (1896) were new names proposed in turn for *Blax*, both of which likewise were found to be preoccupied. Osten Sacken (1886) erected the genus *Cophura* for *sodalis* Osten Sacken from Presidio, Mexico, differentiating *Cophura* from *Blacodes* on a basis of the length of the antennal style. Williston (1901) considered *Blacodes* identical with *Cophura*, further adding several species previously ascribed to *Nicocles* Jaennicke, *Aphamartania* Schiner, and *Taracticus* Loew. Other workers then added new species to the genus.

Seven years later, Hine (1908, p. 203) stated, "There seems to be some uncertainty as to the limits of the genus *Cophura* as used by different authors. . . . It is probable that when a critical study of sufficient material is possible the limits of *Cophura* will be restricted." The next year, Back (1909, p. 377) said, "I firmly believe that the genus *Cophura* as it stands, is more or less of a repository for small asilids of this subfamily that have the front tibiae armed with a terminal claw-like spur and do not fit into any of the other genera. . . . Personally I believe that *sodalis* is distinct from the other species now in the genus. To my knowledge, the only material of this genus in American collections is the type specimens except in the case of *cristata* and *fallei*." The first attempt at reducing this "repository" was made by Curran (1923) in establishing the genus *Comantella* for these last two species mentioned by Back. Melander (1923, p. 209) reiterated, "The genus *Cophura* has been heterotypic, serving to combine various species that run to it in the keys, without regard to their phylogeny. The separation of *Comantella* helps to unify the group, but it is still diverse. The species are considered rare, only the type material being known of most of its forms." Several other species have been separated by Curran under the genus *Buckellia*, with the genotype *Cophura alboscelosa* Hine, but he refrained

from drawing its limits until a comprehensive revision of *Cophura* could be made or at least the genotype studied. *Buckellia* was included in the key to *Cophura* which Curran presented in 1931, largely drawn up from the descriptions. *Cophura panamensis* Curran was recently transferred to the genus *Aphamartania* Schiner (Pritchard, 1941).

Thirty-four species are included in *Cophura* in this revision. Two proposed names which are doubtfully worthy of recognition are retained as varieties. The material examined includes all the species except one, *vitripennis* (Curran) the relationships of which are well established by its describer. Nearly all of the types have been examined. Over five hundred specimens have been studied. The range of the genus has been extended to include South America.

After a preliminary study, it was the writer's impression that there were four major groups worthy of generic rank: a SODALIS GROUP with four species, an ALBOSETOSA GROUP with three species, a BREVICORNIS GROUP with two species, and a FUR GROUP with eighteen species. The eighteen species in the FUR GROUP included two divergent species, *clausa* (Coquillett) and a new species from Nebraska. These two species are more distantly related to the rest of the group and widen its limits. Three additional species, each having bristles over the face, and a new species from Arizona could also have been added to the FUR GROUP, but at the expense of making it still more heterogeneous. Of the remaining species, *sculleni* Wilcox could have been included with the SODALIS GROUP, because this is its closest relationship; but this group is then made rather heterogeneous. *Bella* Loew and a closely allied new species from Mexico, although perhaps also referable to the SODALIS GROUP, possess characters which set them apart. It was then found inexpedient to separate the widened SODALIS and FUR GROUPS. With these united into one large group, it seems unwarranted to elevate the ALBOSETOSA and BREVICORNIS GROUPS to generic rank. It was also deemed unadvisable, if not unjustifiable at the present, to give generic standing to the species not fitting well into larger groups.

For the purpose of this revision, in order to facilitate determination and in order to establish more definitely and easily the morphological relationships, the four major groups are recognized as such, the three species with bristles over the face are recognized as a group, *bella* and its ally are recognized as a group, and the two remaining species are treated individually as representing separate groups. The known species are briefly recharacterized, and notes are given on geographical distribution and seasonal occurrence. Fourteen species are described as new. Diagnostic descriptions of previously known species are largely based on coloration and vestiture and should be considered supplementary to descriptions and comparative notes on the groups which are based principally on morphological characters.

Nothing is known concerning the immature forms of members of this genus. The adults of many species of the FUR and SODALIS GROUPS are found on the tips of grasses or dead twigs of branches, while some species of the FUR GROUP are ground inhabitants. A winged termite has been taken as prey of *Cophura acapulcae*.

The fossil asilid, *Cophura antiquella* Cockerell has been described from the Miocene shales of the Florissant in Colorado. The abdomen

was described as having pollinose markings much as in *fur* (Williston), but the anal cell was described as being closed and petiolate which is not characteristic of *fur* and more closely related species.

For assistance in this study, the writer wishes sincerely to acknowledge his thanks to Mr. Joseph Wilcox who turned over to him some preliminary work on the group, to Dr. R. H. Painter, Dr. R. H. Beamer, Mr. Nathan Banks, Dr. C. H. Curran, Dr. S. W. Bromley, Dr. F. W. Edwards, Mr. H. Oldroyd, Mr. M. T. James, Mr. D. E. Hardy, Prof. M. H. Swenk, Mr. E. G. Anderson, and Mr. C. F. W. Muesebeck, especially for the loan of material, and to Dr. C. E. Mickel and Dr. A. A. Granovsky for advice concerning the execution of this paper.

### Genus *Cophura* Osten Sacken

1872. *Blax* Loew (preoccupied by Koch, 1840; Thompson, 1860; Candèze, 1863), Berl. Ent. Zts., 16: 65. Genotype, *Blax bellus* Loew.  
 1874. *Blacodes* Loew (preoccupied by Dejean, 1834), Berl. Ent. Zts., 18: 377. Genotype, *Blax bellus* Loew.  
 1886. *Cophura* Osten Sacken, Biol. Centr.-Amer., Dipt. I: 181. Genotype, *Cophura sodalis* Osten Sacken.  
 1896. *Loewiella* Williston (preoccupied by Meunier, 1894), Manual N. Amer. Dipt.: 57. Genotype, *Blacodes bellus* (Loew).  
 1901. *Cophura* Williston, Biol. Centr.-Amer., Dipt. I, suppl.: 314.  
 1909. *Cophura* Back, Trans. Amer. Ent. Soc., 35: 375.  
 1923. *Cophura* Melander, Psyche, 30: 208.  
 1925. *Buckellia* Curran, Canad. Ent., 57: 156. Genotype, *Cophura albosetosa* Hine. New synonymy.  
 1931. *Cophura* Curran, Amer. Mus. Nov., 487: 4.

The genus is characterized and separated from all other asilid genera by having the antennal style slender, two segmented, bearing a distal seta which is centrally placed and not situated in a depression; face projecting very little, flat above or gently convex, but little divergent below; prosternum reduced to an isolated plate; mesonotum without a median crest of hairs; anterior tibia with a slender, terminal, sigmoid spur; pulvilli well developed; two submarginal and five posterior cells open at margin; terminal segments of male abdomen unmodified; superior forceps of male genitalia divided but broadly attingent at base; and female ovipositor with spined acanthophorites.

*Genotype*.—*Cophura sodalis* Osten Sacken, by original designation.

*Distribution*.—Restricted to the New World; known from British Columbia, western and southwestern United States, Mexico, Ecuador, and Peru.

### KEY TO GROUPS AND SPECIES

1. Scutellum entirely pollinose..... 2
2. Scutellum with broad posterior margin largely or entirely bare of pollen... 27
2. Wings somewhat ovoid, largely or entirely dark brownish (*SODALIS* GROUP)..... 3
- Wings elongate, slender, hyaline or essentially so, the veins sometimes clouded..... 6
3. Posterior femora yellowish..... 4
- Posterior femora largely black..... 5
4. Face with moderately long hairs on either side; presutural dorsocentrals prominent (southern Mexico) (p. 290)..... *daphne*
- Face with scant setae; presutural dorsocentrals lacking (northern Mexico), (p. 289)..... *sodalis*



5. Male with abdomen reddish (southern Mexico), (p. 289).....**humilis**  
Male with abdomen black (southern Mexico), (p. 290).....**willistoni**
6. **Mystax** composed of strong bristles over face nearly to antennae (TRUNCA GROUP)..... 7  
**Mystax** with bristles oral, on less than lower half of face (FUR GROUP).... 9
7. **Vein R<sub>4</sub>** (Comstock system) with stump of sectoral cross-vein; scutellum with two strong bristles; hind coxa with an elongate tubercle anteriorly; tibiae and tarsi reddish; abdomen partly shining (California), (p. 294),  
**trunca**  
Vein R<sub>4</sub> without stump vein; scutellum with long marginal hairs; hind coxa without tubercle; tibiae and tarsi mostly black; abdomen entirely pollinose..... 8
8. Wings gray; r-m cross-vein but little beyond middle of discal cell; abdominal dark fasciae covering proximal three-fourths of each segment (Ecuador), (p. 295).....**sundra**  
Wings with veins bordered with brown; r-m cross-vein at three-fourths the length of discal cell; abdominal dark fasciae covering proximal half of each segment (Peru), (p. 294).....**zandra**
9. Anal cell closed and short petiolate; tibiae and tarsi yellowish (California), (p. 296).....**clausa**  
Anal cell open..... 10
10. Femora yellowish except at distal end; posterior coxa without anterior tubercle; mesonotum white pilose; abdomen shining black with lateral pollen (Nebraska), (p. 296).....**dora**  
Femora largely or entirely black; posterior coxa with anterior tubercle; mesonotum with short setae and outstanding bristles or with erect brown hair..... 11
11. Abdomen largely bare of pollen dorsally and shining black..... 12  
Abdomen entirely pollinose, except caudal segments of female..... 15
12. Legs with proximal half of tibiae yellowish; cinereous pollen of abdomen forming a lateral stripe (Texas, Oklahoma), (p. 298).....**texana**  
Legs entirely black; cinereous pollen of abdomen lateral, but projecting inward on each segment..... 13
13. Abdominal cinereous pollen extending inward along anterior margin of the segments, meeting to form fasciae on two, three, and four (New Mexico), (p. 298).....**ameles**  
Abdominal cinereous pollen extending inward along posterior margins of the segments, well separated dorsally..... 14
14. Mesonotum with conspicuous, erect, brown hair (southern Mexico), (p. 297),  
**pulchella**  
Mesonotum nearly bare (Arizona), (p. 297).....**fur**
15. Anterior calli of mesonotum bearing short bristles..... 16  
Anterior calli of mesonotum only pollinose..... 20
16. Femora black..... 17  
Femora with at least middle pair yellowish behind..... 19
17. Anterior four tibiae reddish, infuscate at tip; abdomen ochreous-brown fasciate (southern Mexico), (p. 299).....**cora**  
Anterior four tibiae black or with not over proximal two-thirds of anterior pair and proximal third of middle pair yellowish; abdomen dark brown fasciate..... 18
18. Dorsocentrals postsutural; mesonotal and scutellar bristles white, sometimes brown in part; typically with anterior four tibiae reddish proximally; abdominal fasciae even; male genitalia with short hairs (Arizona), (p. 299).....**arizonensis**  
Dorsocentrals strong anterior to transverse suture; mesonotal and scutellar bristles all black; legs entirely black; abdominal fasciae much narrowed medially; male genitalia with long pile (southern Mexico), (p. 300).....**igualae**
19. Mesonotal and scutellar bristles black; abdomen dark brown fasciate; one pair of marginal scutellars (southern Mexico), (p. 301).....**atypha**  
Mesonotal and scutellar bristles pale; abdomen rich brown pollinose above; two pairs of marginal scutellars (southern Mexico), (p. 301).....**apotma**
20. Scutellum without bristles..... 21  
Scutellum with marginal bristles..... 22

21. Legs black; body cinereous pollinose with dark brown markings (southern Mexico), (p. 302)..... **acapulcae**  
 Legs with tibiae reddish-yellow proximally; body reddish-brown pollinose with dark brown markings (southern Mexico), (p. 303)..... **calla**
22. Scutellum with a single pair of marginal bristles..... 23  
 Scutellum with two or three pairs of marginal bristles..... 25
23. Posterior femora with numerous long bristles below, without fine hairs; femora usually with distal ends reddish, especially posteriorly; abdomen uniformly cinereous pollinose (Oklahoma, Kansas, Colorado, Texas), (p. 304)..... **stylosa**  
 Posterior femora with three or four slender bristles below and a few short, fine hairs; femora entirely black; abdominal pollen brown or brownish fasciate..... 24
24. Abdomen with dorsum uniformly dark brown pollinose contrasting with a lateral cinereous stripe; wings largely fuliginous on distal half; median plate of male genitalia sharply convex distally, without indentation (Arizona), (p. 304)..... **hesperia**  
 Abdominal tergites cinereous pollinose posteriorly; wings hyaline; median plate of male genitalia nearly flat with a median indentation on distal third (Arizona), (p. 304)..... **pollinosa**
25. Anterior tibiae black; abdominal tergum dark brown pollinose with a cinereous stripe on each side (Arizona), (p. 305)..... **vera**  
 Anterior tibiae reddish-yellow on proximal three-fourths..... 26
26. Abdomen cinereous pollinose or tinged with brownish dorsally (Colorado, Arizona, New Mexico, Texas), (p. 305)..... **lutzi**  
 Abdomen cinereous pollinose, with dorsal brown fasciae (Oklahoma), (p. 305)..... **lutzi** var. **wilcoxi**
27. Posterior coxa without tubercle..... 28  
 Posterior coxa with elongate tubercle anteriorly..... 29
28. Face with only oral bristles and hairs, and at narrowest point fully two-thirds as wide as width of one eye; thorax nearly bare of hairs and bristles; wings long and slender; hind tibiae slender; brown species with brown legs and hyaline wings (PAINTERI GROUP), (Arizona), (p. 293)..... **painteri**  
 Face hairy, at narrowest point about one-half as wide as width of one eye; thorax pilose; wings broad at base and strongly tapering; hind tibiae stout, enlarged; species with black thorax, yellow abdomen and legs, and with wings dark brown on proximal two-thirds (SCULLENI GROUP), (Arizona, New Mexico), (p. 291)..... **sculleni**
29. Anal cell closed and petiolate; scutellum nearly as long as wide, somewhat triangular, the caudal margin with a bare spot on either side; wings broadly rounded; mesonotum with dorsocentrals well differentiated; reddish species with brown wings (BELLA GROUP)..... 30  
 Anal cell open; scutellum twice as wide as long, the caudal margin well rounded and entirely bare of pollen; wings elongate; mesonotum without dorsocentrals well differentiated; black species with more hyaline wings... 31
30. Mesonotal pollen of male white anteriorly, gradually diffusing posteriorly into the ochreous pollen; five pairs of dorsocentrals (Texas, New Mexico), (p. 291)..... **bella**  
 Mesonotal pollen of male very densely white anteriorly, extending posteriorly three-fifths of distance to transverse suture, and sharply differentiated from the yellowish-brown mesonotal pollen; one pair of strong dorsocentrals (northern Mexico), (p. 292)..... **nephressa**
31. Mesonotum clothed with stout setae; scutellum without discal hairs, the caudal margin with one or two pairs of bristles; face nearly bare of hairs above; abdomen punctate (BREVICORNIS GROUP)..... 32  
 Mesonotum clothed with erect hairs; scutellum hairy, with a marginal row of long hairs; face clothed with erect hairs; abdomen smooth (ALBO-SETOSA GROUP)..... 34
32. Tibiae with appressed hairs white (New Mexico), (p. 306)..... **caca**  
 Tibiae with appressed hairs black..... 33
33. Legs castaneous (Washington, Oregon, Colorado, Nebraska), (p. 306), **brevicornis**  
 Legs black (Idaho, Montana, California), (p. 306), **brevicornis** var. **melanochaeta**

34. Legs entirely black.....35  
 Legs with broad apices of femora, tibiae except apices, and bases of first two or three tarsal segments pale yellowish; wings hyaline (British Columbia), (p. 308).....**vitripennis**
35. Wings with cross-veins and furcations broadly clouded with brown (Washington, Oregon), (p. 307).....**scitula**  
 Wings hyaline, or essentially so in male (British Columbia, Washington, Oregon, Utah), (p. 308).....**albosetosa**

## COMPARATIVE NOTES ON THE GROUPS

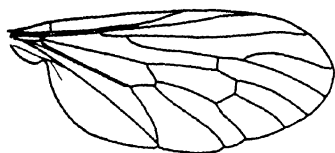
The shape of the face and the composition of the mystax have been considered paramount by some workers for splitting *Cophura*. With all the species at hand, these characters do not lend themselves to ready differentiation into groups, and in correlation with other characters cannot be considered of generic value at the present. The face at its narrowest point just below the antennae is about one-half the width of one eye in SCULLENI, three-fifths the width of one eye in FUR and TRUNCA, and about two-thirds the width of one eye in the other groups, but the differences are not well delimited. As seen from the side, the face is distinctly and evenly convex in ALBOSETOSA and nearly so in BREVICORNIS, and rather evenly rounded but not produced in SCULLENI and *dora*. In the other groups the face is not receding orally, and in TRUNCA is built up to a well marked supra-oral projection. The face is gently curved to the oral projection in the remaining groups, but flattened above in some species of FUR. The bristles of the mystax cover most of the face in TRUNCA, but are mostly oral in the other groups. The hairs on the face are small and scant in PAINTERI, BELLA, BREVICORNIS, and in most species of FUR and SODALIS; longer, moderate to rather dense in SCULLENI, a few species of FUR, and ALBOSETOSA. The antennal style is shorter than the length of the second antennal segment in SODALIS, SCULLENI, and PAINTERI, as long as the second antennal segment or longer in the other groups.

The entire absence of scutellar hairs or bristles does not usually occur in SODALIS as indicated by Osten Sacken (1886) and used by Curran (1934) and James (1941) to separate *Cophura* from *Buckellia*, but this condition does occur in two species of FUR. The use of the lack of marginal pollen of the scutellum as a primary division in the key is not necessarily a character for separating groups, but it is warranted by the convenience of this character with the material at hand.

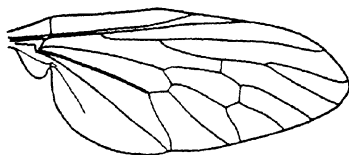
The middle tibia at the tip inside bears a single, significant black spine in SODALIS, SCULLENI, PAINTERI, and BELLA; two divergent terminal spines in *clausa* and *dora*, one spine of which is usually yellow-

## EXPLANATION OF PLATE I

1. Wing of *Cophura bella* (Loew); Estancia, New Mexico; August 11, 1931.  
 2. Wing of *C. sculleni* Wilcox; holotype, male. 3. Wing of *C. sodalis* Osten Sacken; cotype, female. 4. Wing of *C. fur* (Williston); Phoenix, Arizona, April 13, 1931.  
 5. Anterior and lateral views of head of *C. sodalis* Osten Sacken; cotype, female.  
 6. Anterior and lateral views of head of *C. brevicornis* (Williston); Puyallup, Washington, July 27, 1935; female. 7. Anterior view of head of *C. fur* (Williston); Phoenix, Arizona, April 19, 1931; female. 8. Lateral view of head of *C. zandra*, new species; holotype, female. 9. Anterior view of head of *C. sculleni* Wilcox; holotype, male. Figures 1-4 drawn to same scale; figures 5-9 drawn to same scale.



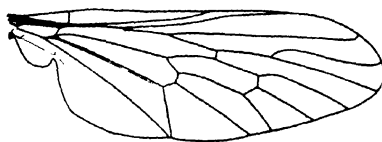
1. *BELLA*



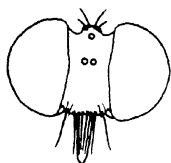
2. *SCULENI*



3. *SODALIS*



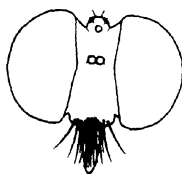
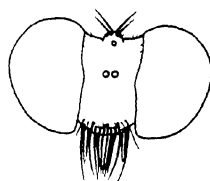
4. *FUR*



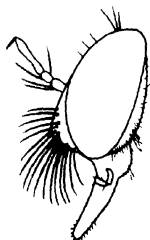
5. *SODALIS*



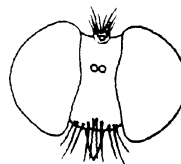
6. *BREVICORNIS*



7. *FUR*



8. *ZANDRA*



9. *SCULENI*

ish; and at least a pair of adjacent black spines in the other groups. The posterior coxa is without an anterior tubercle in SODALIS, SCULLENI, PAINTERI, two species of TRUNCA, and one species, *dora*, included in FUR, but bears an elongate tubercle in the other groups. This tubercle is not necessarily of importance, but with the species at hand seems to indicate close relationships.

The wings are broad proximally and tapering distally in SODALIS and SCULLENI, more broadly rounded in BELLA, and elongate in the other groups. The color of the wings is fumose, often lighter on the distal third in SODALIS; fumose, but hyaline on the distal third in SCULLENI; fumose with a costal clear spot in BELLA; and essentially hyaline or grayish, although often with flavescence or infuscation especially along the veins, in the other groups. The anal cell is closed and short-petiolate in SODALIS, BELLA, and *clausa*, closed in the margin in SCULLENI, and open or rarely closed in the margin in the other groups. Vein  $R_4$  bears a long stump vein only in one species of TRUNCA; rarely there is an indication of this stump vein at the fork of  $R_4$  and  $R_5$  in ALBOSETOSA.

The ground color of the abdomen is reddish in SCULLENI, BELLA, and in most species of SODALIS; it is essentially black in the other groups. The abdomen is punctate in BREVICORNIS, smooth or pollinose in the other groups. The form of the abdomen does not lend itself readily to group division. The abdomen is rather broad and distinctly flattened in SODALIS and SCULLENI, more elongate, somewhat flattened to distinctly convex in the other groups.

### SODALIS GROUP

Face distinctly rounded on lower third, receding orally very little, at antennae fully two-thirds the width of one eye; inner eye margins slightly divergent above and below antennae, about equally in both directions. Mystax sparse, composed of long oral bristles and from a few to moderately dense fine hairs above on either side which may be as long as first two antennal segments. Antennae with proximal two segments subequal, the third about one and one-third times the length of first two combined, parallel sided, tapering somewhat at distal end; style short, about half the length of first antennal segment, with a small distal seta, two segmented with the proximal division very short. Thorax entirely pollinose. Mesonotum moderately hairy or nearly bare, the dorsocentrals long, postsutural or over the entire dorsum. Scutellum convex, one-half as long as broad, well rounded on caudal margin which bears several pairs of small setae which are rarely over half as long as length of scutellum. Posterior coxa without an anterior tubercle; anterior tibia with distal spur slender, sigmoid; middle tibia with a single black distal spine inside; posterior tibia slender, evenly tapering to base; pulvilli nearly as long as the claws. Wings short and quite broad subproximally, tapering on distal half; fourth posterior cell but little narrowed; anal cell closed and short petiolate. Abdomen shorter than wings, quite flattened, tapering gradually from at or near base, especially in female; above bare or thinly pollinose. Male genitalia completely exerted, normally inverted; ninth tergite of female evenly rounded.

Within the single species *humilis* (Bellardi), there is found a series of antennal conditions ranging from the presence of a complete proximal segment in the style to the presence of this segment only as a small nodule at one side of the base of the style.

### **Cophura sodalis** Osten Sacken

1886. *Cophura sodalis* Osten Sacken, Biol. Centr.-Amer., Dipt. I: 181.

A yellowish pollinose species with fumose wings and yellowish abdomen. Mesonotal vestiture very short and sparse; three pairs of short, yellow dorsocentrals posteriorly. Legs yellowish with brown infuscation on proximal two-thirds of anterior four femora, distal ends of anterior four tibiae and tarsi, distal third of posterior tibiae, and distal ends of posterior tarsal segments. Length, 5–8 mm.

*Types*.—Described and known only from one male and nine females from Presidio, Mexico; types deposited in the Museum of Comparative Zoology and the British Museum (Natural History).

Two cotype females have been seen, one from each museum. Two females from Lower California differ in having the abdomen dark brown and the thoracic setae more strongly developed; these probably represent a new species. A female from Ruby, Arizona (July 13, 1940), differs essentially in having the wings darker with the costal margin hyaline to the end of the marginal cell; this probably represents a new species.

### **Cophura humilis** (Bellardi)

1861. *Dasyopogon* (? *Heteropogon*) *humilis* Bellardi, Saggio Ditt. Mess., 2: 77.

1901. *Cophura sodalis* Williston (not Osten Sacken), Biol. Centr.-Amer., Dipt. I, suppl.: 314.

Face moderately clothed with fine white hairs on either side. Mesonotum covered with numerous erect setae, with long dorso-centrals over most of its length. Legs with femora black except tip; tibiae yellowish, black on tips of anterior two pairs and on distal third of posterior pair; tarsi blackish. Wings fuscous, the distal third or more usually lighter and sometimes nearly hyaline. Abdomen yellowish in both sexes, usually blackish at base and tip, and to a variable extent below. Length, 6–9 mm.

*Types*.—Described from Cuantla, Guerrero, Mexico, from one male; probably at the Museum of Geneva.

Although Bellardi has apparently overlooked the tibial spur, there is little doubt but that his species belongs here. Williston recorded two females from Guadalajara, Jalisco, Mexico, under the name of *Cophura sodalis*; these specimens are in the British Museum (Natural History), and have been examined by the writer. A large series was taken by the writer at Acapulco, Guerrero, Mexico (June). It was found to be abundant on the tips of low weeds along the coast, being replaced by *Cophura acapulcae* in the adjacent coastal range. The species bears a striking resemblance to *Holcocephala abdominalis* (Say); both Osten Sacken and Back commented on this with regard to *sodalis*. It might be noted that the types of wing and abdominal shapes among the species of *Holcocephala* Jaennicke are as diverse as among the species of *Cophura*.

***Cophura willistoni*, new name**

1901. *Cophura humilis* Williston, Biol. Centr.-Amer., Dipt. I, suppl.: 315 (pre-occupied by Bellardi, 1861).

The male of this species differs from *humilis* (Bellardi) by having the abdomen black with the segmental posterior margins narrowly yellow. The female ascribed to the species by association is hardly differentiable from Bellardi's species.

*Types*.—Williston described the species from a male and female, Tepetlapa, Guerrero, Mexico; types probably in the British Museum (Natural History).

The author took four males and one female at Iguala, Guerrero, Mexico (June).

***Cophura daphne*, new species**

Black, with yellowish pollen and vestiture, the abdomen and legs except tarsi and distal half of posterior tibia yellowish; wings brown, paler distally. Length, 7.5 mm.

*Male*.—Head light yellowish pollinose; vestiture light yellowish, the beard and hairs on the face nearly white. Mystax composed of a row of oral bristles and moderately long hairs on either side of the face extending nearly to the antennae; four ocellars longer than proximal two antennal segments; parafrontals longer than proximal antennal segment. Thorax and coxae ochreous pollinose, the mesonotum with geminate median vitta and wide lateral vittae thinly brown pollinose, largely shining black. Thoracic vestiture yellowish; mesonotum covered with numerous erect setae anteriorly; dorsocentrals extending presuturally. Scutellum entirely pollinose, with five pairs of marginal setae. Legs yellowish, the posterior tibia blackish on distal half, the anterior four tarsi blackish distally, the posterior tarsi blackish. Wings deeply fuscous, paler on distal third and in the cells of the anal field; anal cell closed and petiolate. Abdomen yellowish with sparse pale yellow setae, and lateral yellowish bristles on first segment. Genitalia reddish-yellow, black distally, clothed with yellowish bristles.

*Holotype*.—Male, Cuernavaca, Morelos, Mexico, 1923 (E. G. Smyth) in the United States National Museum.

*Daphne* differs from other members of the SODALIS GROUP by having the face more produced, the hairs of the face denser and longer, the ocellars and the parafrontals much stronger. This species is most closely related to *humilis* (Bellardi) which, however, does not have yellow femora.

**SCULLENI GROUP**

This group differs from the SODALIS GROUP to which it is closely related, by having the face more evenly curved and narrower, at its narrowest point just below the antennae but little over half the width of one eye; front nearly parallel sided; facets of the eyes smaller; scutellum broadly bare of pollen on its caudal margin; posterior tibiae

much stouter; anal cell narrowly open or closed in the margin; and male genitalia concealed from above.

### ***Cophura sculleni* Wilcox**

1937. *Cophura sculleni* Wilcox, Pan.-Pac. Ent., 13: 69.

Thorax yellowish-gray pollinose; mesonotum clothed with moderately dense, fine white hairs, with dorsocentrals postsutural; scutellum with shining black posterior margin, with several marginal hairs about as long as scutellum. Legs yellowish with distal ends of tibiae and most of tarsi black. Wings with proximal two-thirds fumose, the distal third clear hyaline and contrasting. Abdomen reddish, black at base. Length, 7 mm.

*Types*.—Holotype, male, Holbrook, Arizona (June), in the collection of Mr. J. Wilcox; and allotype, female, Estancia, New Mexico (July), in the collection of Dr. S. W. Bromley.

Specimens examined are the holotype; one male, three females, Alamogordo, New Mexico, June 26, 1940 (D. E. Hardy); one male, two females, 25 miles west of Tularosa, New Mexico, July 1, 1940 (D. E. Hardy).

### **BELLA GROUP**

This group exhibits very close relationships to *Nicocles* Jaennicke, differing only in having the terminal abdominal segments of the male undilated. It differs from the SODALIS GROUP by having the scutellum a little longer, subtriangularly shaped, bare of pollen on either side, marginally with two scutellars and a few small hairs; hind coxae with anterior tubercle; abdomen slender, well rounded above; posterior tibia enlarged at distal end; and male genitalia concealed from above. BELLA differs from the FUR GROUP principally by having the scutellum as described; wings rather oval; anal cell closed and petiolate; middle tibia with a single spine inside at tip; and male genitalia completely concealed from above.

### ***Cophura bella* (Loew)**

1872. *Blax bellus* Loew, Berl. Ent. Zts., 16: 63.

1874. *Blacodes bellus* Loew, Berl. Ent. Zts., 18: 377.

1885. *?Aphamartania bella* Williston, Trans. Amer. Ent. Soc., 12: 54.

1896. *Loewiella bella* Williston, Manual N. Amer. Dipt.: 57.

1901. *Cophura bella* Williston, Biol. Centr.-Amer., Dipt. I, suppl.: 314.

1909. *Cophura bella* Back, Trans. Amer. Ent. Soc., 35: 379.

1934. *Cophura bella* Bromley, Ann. Ent. Soc. Amer., 27: 102.

A reddish species with yellowish vestiture. Face white pollinose; mystax composed of oral bristles and a few small hairs above on either side. Thorax ochreous pollinose. Mesonotum sparsely clothed with hairs, in male white pollinose on anterior half between calli and middorsal stripe; middorsal stripe brown, running full length of mesonotum; dorsocentrals long, yellowish, with two pairs presutural. Legs yellowish-red; femora brownish on distal half except tip, less so on posterior pair; tibiae blackish at tip, more so on posterior pair; tarsal segments with distal half brown. Wings fumose,



often with cells pale within, and with a nearly hyaline spot between the furcation of  $R_4$  and  $R_5$  and the costal margin. Abdomen shining yellowish or reddish, white pollinose laterally except on caudo-lateral corners of tergites which are often blackish in ground color, especially on posterior segments. Length, 6–9 mm.

*Types*.—Cotypes, male and female, Texas; in the Museum of Comparative Zoology.

This species has been unrecognized since described. Other specimens examined are two males, five females, Estancia, New Mexico, August 10–11 (R. H. Painter), and two males, four females, Gran Quivera, New Mexico, August 13, 1931 (R. H. Painter).

### ***Cophura nephressa*, new species**

Body black except scutellum, abdomen and legs in part yellowish; pollen yellowish-brown except for white face and front, anterior coxae, and sharply outlined area anteriorly on mesonotum. Wings brown with a costal clear spot. Length, 9 mm.

*Male*.—Face and front densely white pollinose; occiput yellowish pollinose. Mystax composed of a mixed row of yellowish bristles and several fine white hairs above on either side; ocellars two, long and yellowish. Second antennal segment slightly longer than first; third twice as long as proximal two combined; style nearly as long as first two antennal segments combined. Thorax largely yellowish-brown pollinose, the coxae lighter and the anterior coxae white; the mesonotal area between the anterior calli and covering three-fifths of the distance anterior to the transverse suture densely white pollinose and strongly contrasting; median and lateral vittae of mesonotum dark brown pollinose, the median vitta being widely divided and largely obscured anteriorly. Mesonotal setae nearly lacking; two strong dorsocentrals and four lateral bristles yellowish. Scutellum subtriangular, yellowish in ground color, thinly ochreous pollinose except for shining bare spot on either side of caudal margin, with several yellowish scutellars. Legs largely reddish, fuscous above on femora and on distal ends of tibiae and tarsal segments; clothed with yellowish hairs and bristles. Wings brownish, darker distally and proximally to a costal hyaline spot which is at the end of the submarginal cell; anal cell closed and petiolate. Abdomen elongate, yellowish, nearly bare.

*Holotype*.—Male, Galeana, Nuevo Leon, Mexico, 5–6000 ft., August 2, 1939 (Ralph Haag); in the Musuem of Comparative Zoology.

Closely allied to *bella* (Loew) from which it differs mainly in being considerably more elongate, in lacking evident mesonotal setae anteriorly, and in having only one pair of well developed dorsocentrals; and by having the white pollinose area of the male mesonotum denser and strongly contrasting.

### **PAINTERI GROUP**

This group could probably be united with the **FUR GROUP** to which it is most closely related, but in many respects it is intermediate between this and the **SODALIS GROUP**. It differs from typical **FUR** by having

the face a little wider, antennal style shorter, scutellar margin broadly bare of pollen and clothed with a fringe of very short hairs, posterior coxa lacking the anterior tubercle, middle tibia with a single black spine inside at tip, and abdomen strongly flattened. *PAINTERI* differs from *SODALIS* by having the scutellum as described, wings elongate and nearly parallel sided, and anal cell open. The face is hardly flattened above, and but slightly projecting orally. The legs are slenderer than in any other species of *Cophura*. The pollinosity pattern of the abdomen is similar to that of the *BREVICORNIS* GROUP, but the integument is smooth and shining.

### *Cophura painteri*, new species

A brown species with sparse white hairs and bristles. Legs brown; wings hyaline; abdomen shining brown with white pollen on anterior margins and caudo-lateral angles of the segments. Length, 6 mm.

*Female*.—Face, front, and vertex thinly brown pollinose; rear of head cinereous pollinose. Mystax white, oral, composed of four bristles in center, one on either side, and a few white hairs; ocellar tubercle with two white bristles. First antennal segment slightly longer than second; third nearly two and one-half times length of proximal two combined, strongly laterally compressed, tapering a little from near base; style a little less than length of second antennal segment. Thorax thinly whitish pollinose laterally, brownish pollinose above. Mesonotum with ill defined markings, clothed with inconspicuous, short, white hairs, and with only one strong pair of dorso-centrals. Scutellum cinereous pollinose, the posterior margin bare, shining, with a fringe of small, fine hairs. Legs slender, brownish, the tibiae paler proximally; clothing scant, white. Wings elongate, hyaline; veins light brown. Vein  $R_5$  forming a straight line with  $R_{4+5}$ ; r-m cross-vein at two-thirds length of discal cell; fourth posterior cell a little narrowed; anal cell narrowly open. Abdomen shining brown; side of segment one white pollinose; caudo-lateral angles of two to five with white pollinose trapezoids; anterior margin of two to five thinly white pollinose, the fasciae narrowed at center and on sides. Eighth tergite evenly rounded, the posterior margin slightly undulate.

*Holotype*.—Female, Safford, Arizona, VII-26 (F. M. Hall), in the collection of Dr. R. H. Painter in whose honor the species is named.

### TRUNCA GROUP

Closely related to the *FUR* GROUP with which it might be placed. It differs by having the bristles of the mystax extending over the face nearly to the antennae, and the face built up to a well marked supraoral projection. In *sundra*, however, the face is low enough to be intermediate between this and the *FUR* GROUP. *Trunca* differs structurally from the two South American species included in this group principally by having the thorax more highly arched, vein  $R_4$  having a well developed stump vein, and the posterior coxa with an elongate tubercle anteriorly.

**Cophura trunca** (Coquillett)1893. *Blacodes truncus* Coquillett, *Canad. Ent.*, 25: 34.1909. *Cophura trunca* Back., *Trans. Amer. Ent. Soc.*, 35: 383.1916. *Cophura highlandica* Cole, *Psyche*, 23: 63, fig. New synonymy.

Body black, with cinereous and ochreous pollen and black and whitish vestiture. Length, 8–9 mm.

*Male*.—Mystax pale, upper bristles brownish; ocellar tubercle with four very long, strong black bristles and several small, white hairs; first two antennal segments with black bristles below, longer than the length of the two segments combined. Thorax ochreous pollinose; mesonotum with vestiture black except for yellow bristles on anterior calli; dorsocentrals long, along entire length of mesonotum, and with a row of black hairs between them; scutellum with two strong marginal bristles and discal and marginal hairs. Legs with femora black except tips; tibiae and tarsi yellowish. Wings hyaline with furcations and cross-veins broadly brown maculate. Abdomen with cinereous pollen narrowly along anterior margin of the segments which is unconnected with lateral pollen.

*Female*.—Differing in the abdomen which has the caudal segments reddish-brown in color; and pollen more extensive, covering each side from the middle of the anterior margin of each segment to the caudolateral corners, enclosing a lateral bare spot.

*Types*.—*Trunca* was described from two males and two females, Los Angeles Co., California (Coquillett), deposited in the U. S. National Museum; *highlandica* was described from a female, East Highlands, California (November), in the U. S. National Museum.

A male and female on the same pin *in copula* and two other females, all from Los Angeles Co., California (Coquillett), are in the U. S. National Museum; one female bears a red type label. The types of *highlandica* and *trunca* have been compared by the writer and found to be the same. *Cophura trunca* is very closely related to *Metapogon punctipennis* Coquillett and *Metapogon pictus* Cole, not only in facial and thoracic structure and wing venation, but also in abdominal pollinose markings. Were it not for the presence of the tibial spur in *trunca*, it would be considered cogenetic with these two species of *Metapogon*.

**Cophura zandra**, new species

Elongate species; body black, brown pollinose; the abdomen with dark brown fasciae. Legs black; wings with brown suffusion along the veins. Length, 10 mm.

*Female*.—Head anteriorly brown pollinose; posteriorly cinereous pollinose; vestiture yellowish to brown. Mystax reaching nearly to antennae, darker above, composed almost entirely of bristles; ocellar tubercle with eight brown bristles. Face just below the middle projecting beyond the eyes, as seen from the side, by a distance fully as long as the first antennal segment. Second antennal segment a little shorter than first; third twice as long as combined length of first two, laterally compressed, broadly coarctate near middle, tapering only at tip; style one-third as long as third segment. Mesopleura

brownish-cinereous pollinose. Mesonotum brown pollinose with wide middorsal and lateral vittae dark brown; clothed with inconspicuous brownish hairs; dorsocentrals long, dark brown, with several pairs presutural. Scutellum entirely brown pollinose, brown pilose, with eight long, marginal, whitish hairs. Legs black, the bases of the tibiae very narrowly reddish; vestiture yellowish to brown; long, pale hairs on the femora especially noticeable. Wings brownish, the veins all bordered with brown, especially dark at the base of radial sector. Discal cell very long, with r-m cross-vein at three fourths its length; medial cross-vein twice length of base of  $M_2$ ; fourth posterior cell well narrowed; anal cell open. Abdomen elongate, sparsely white pilose laterally, with short brown and yellowish hairs; laterally with narrow cinereous pollinose stripe, dorsally with brown pollen, on proximal half of each segment dark brown forming fasciae which are a little extended at middle and on each side.

*Holotype*.—Female, Celendin, Cajamarca, Peru, July 3, 1936 (Felix Woytkowski), at the University of Minnesota.

#### ***Cophuraundra*, new species**

Slender species. Black, largely brown pollinose, the abdomen fasciate. Legs black; wings gray. Length, 8 mm.

*Male*.—Pollen of front dark brown, of face ochreous, behind head cinereous. Bristles of occiput and narrow oral margin pale yellowish. Mystax composed of black bristles, extending to antennae; several pairs of long bristles on first two antennal segments also black. Face supraorally, as seen from the side, projecting by a distance as great as the length of the first antennal segment. Second antennal segment slightly shorter than first; third twice as long as first two combined, laterally compressed, broadly constricted near middle; style one-half as long as third segment. Mesopleura brownish-cinereous pollinose; mesonotum largely dark brown pollinose. Hairs of pronotum and anterior calli pale yellowish; erect hairs on mesonotum and long dorsocentrals along entire length, black. Scutellum brownish pollinose, the disc pale pilose, the caudal margin with several pairs of long black hairs. Legs black, with pale vestiture. Wings even grayish. R-m cross-vein near middle of discal cell; medial cross-vein equal in length to base of  $M_2$ ; fourth posterior cell not narrowed distally; anal cell open. Abdomen slender, clothed with yellowish setae and with whitish hairs laterally, dark brown pollinose on proximal three-fourths of each segment, ochreous pollinose on caudal fourth.

*Holotype*.—Male, Pondo, Ecuador, December 1, 1938 (W. Clarke-McIntyre), at the University of Minnesota.

*Paratypes*.—Two males, Pondo, Ecuador, December 1, 1938 (W. Clarke-McIntyre), in the writer's collection.

Closely related to *zandra*, differing essentially in being slenderer, having grayish wings, with the r-m cross-vein near the middle of the discal cell and the two veins at the end of the discal cell subequal, the fourth posterior cell wider distally, and the dark fasciae of the abdomen much broader. The hairs of the mesonotum, and the bristles of the face, antennae, and ocellar tubercle are black rather than brownish.

## FUR GROUP

Differs from the SODALIS GROUP in having the face a little narrower, the posterior coxa with an elongate tubercle, wings slender with anal cell open, and elongate, not as distinctly flattened. *Clausia* diverges from the typical FUR by having the anal cell closed and short petiolate, abdomen well rounded above, and male genitalia smaller, mostly concealed from above, with the median plate and lateral forceps poorly developed. *Dora* diverges from the typical FUR by having the face receding orally, and the posterior coxa lacking the anterior tubercle.

***Cophura clausa* (Coquillett)**

1893. *Blacodes clausus* Coquillett, Canad. Ent., 25: 34.

1909. *Cophura clausa* Back, Trans. Amer. Ent. Soc., 35: 381, pl. 9, fig. 7.

1941. *Cophura clausa* James, Jour. Kans. Ent. Soc., 14: 33.

Body black with cinereous pollen and pale vestiture. Length, 6–8 mm.

*Male*.—Mesonotum with dark brown, geminate middorsal stripe; clothed with short hairs; with long dorsocentrals except at anterior end. Scutellum with two strong marginal bristles and a few short hairs on disc and margin. Legs with femora black; tibiae and tarsi reddish. Wings hyaline or with a faint brownish tinge. Abdomen above largely shining black; cinereous pollen forming caudo-lateral triangles, a median line on proximal half of each segment which is wider on posterior segments, and a narrow anterior margin on two, three, and four.

*Female*.—Similar to male, but abdomen with the tergum pollinose except for the posterior margins of the segments and sometimes a triangle in the middle of each side of segments two, three, and four.

*Types*.—Cotypes, three males and six females, Orange Co., California, deposited in the U. S. National Museum.

Two males and five females, Los Angeles Co., California (Coquillett), are in the U. S. National Museum; one female bears a red type label. Additional material examined includes a female, Balboa, California (October), and a female, San Pedro, California (Sept.). The record of *clausa* from Durango, Colorado (June), by James should not be accepted until checked. *Cophura clausa* is very closely related to *Metapogon gilvipes* Coquillett, both in body structure and wing venation, and would be considered cogenetic with this species but for the tibial spur.

***Cophura dora*, new species**

Slender species. Black, cinereous pollinose and white pilose; abdomen with caudo-lateral pollinose triangles; wings hyaline with light yellow veins; legs largely yellowish. Length, 8–9 mm.

*Male*.—Head cinereous pollinose, with hairs and bristles white. Face covered with long, rather erect hairs and with oral bristles; ocellar tubercle with numerous long bristles. Second antennal segment slightly shorter than first; third but slightly longer than first two combined, broad near base and tapering to tip; style slender, nearly two-thirds as long as third segment. Thorax cinereous pollinose, the mesonotum light brownish. Mesonotum rather densely

white pilose, the bristles poorly differentiated. Scutellum entirely pollinose, without discal hairs, with two pairs of long marginal hairs. Legs largely bright yellowish; coxae blackish; the anterior two pairs of femora blackish above at distal end, and anterior two pairs of tibiae blackish at tip; posterior femora blackish on distal fifth, and posterior tibiae blackish on distal third; tarsi blackish, the bases of the segments yellowish. Vestiture of legs whitish, rather sparse. Wings hyaline, the veins light yellowish; anal cell open; fourth posterior cell but little narrowed. Abdomen elongate, convex above, subspatulate, segment two being constricted. Abdomen clothed with white pile laterally and below, white setae above; shining black, with cinereous pollinose triangles covering the caudo-lateral angles of the segments, forming a narrow lateral stripe, and less widely separated above on caudal segments. Genitalia black, the superior forceps yellowish distally; white pilose.

*Female*.—Similar, but the pollen on abdominal segments six and seven forming only a lateral stripe.

*Holotype*.—Male, Mitchell, Nebraska, July 29, 1912 (L. M. Gates), at the University of Nebraska. *Allotype*.—Female, Mitchell, Nebraska, August 5, 1912 (L. M. Gates), at the University of Nebraska. The holotype bears the label, "new genera and species," possibly by Paul R. Jones.

*Paratypes*.—One female, Mitchell, Nebraska, August 16, 1915 (E. M. Partridge); one female, Mitchell, Nebr., July 30, 1913 (L. M. Gates); and one female, Mitchell, Nebr., Aug. 6, 1913 (L. M. Gates).

*Dora* differs from all other members of the FUR GROUP by having the face more receding orally, by lacking the tubercle on the posterior coxa, by having the femora and tibiae bright yellowish except at tips, the mesonotum white pilose, and the abdomen rather spatulate. The pollinose pattern of the abdomen is similar to that of *fur*.

### *Cophura fur* (Williston)

1885. *Aphamartania fur* Williston, Trans. Amer. Ent. Soc., 12: 53.

1901. *Cophura fur* Williston, Biol. Centr.-Amer., Dipt. I, suppl.: 314.

1909. *Cophura fur* Back, Trans. Amer. Ent. Soc., 35: 381, pl. 9, fig. 6.

Black, cinereous pollinose; especially characterized by having the vestiture sparse; the abdomen bare of pollen above, cinereous pollinose laterally with the pollen extending triangularly inward on the caudal margin of each segment. Legs black. Wings flavescent to a variable extent on distal half or two-thirds. Length, 7–9 mm.

*Types*.—One male from Arizona, which is at the University of Kansas.

This species has been unrecorded since described. Material examined includes three males, five females, Phoenix, Arizona, April 13–18, 1931 (E. M. Painter).

### *Cophura pulchella* Williston

1901. *Cophura pulchella* Williston, Biol. Centr.-Amer., Dipt. I, suppl.: 314.

Coloration and pattern similar to that of *fur*. Body, however, more robust and vestiture much denser. Wings light brownish.

Abdomen of male with pollen on fifth, sixth and seventh segments connected dorsally. Length, 8 mm.

*Types*.—Seven specimens, Venta de Zopilote, Guerrero, Mexico, 2800 ft.; partly in the American Museum of Natural History and probably partly in the British Museum (Natural History). Unrecorded since described.

### *Cophura ameles*, new species

Related to *fur* from which it differs by having the wings clear hyaline, the veins yellowish rather than brown; and abdomen with cinereous pollen projecting triangularly inward on anterior margin of each segment, meeting to form fasciae on two, three, and four. Length, 9 mm.

*Female*.—Head cinereous pollinose, the vertex nearly bare. Mystax composed of a few oral bristles and a few short, fine white hairs above on either side. Proximal two antennal segments subequal, clothed with short, white bristles. Thoracic pleura cinereous pollinose, tinged with brown on mesopleura. Mesonotum brownish-cinereous pollinose, brown between anterior calli; vittae wide, thinly pollinose, recognizable by the black ground color; clothed with inconspicuous, small white hairs, white lateral bristles, and two pairs of small, hardly distinguishable dorsocentrals posteriorly. Scutellum entirely cinereous pollinose, with two pairs of white bristles on caudal margin. Legs black, the tibiae faintly reddish at extreme base; moderately clothed with white hairs and bristles. Wings hyaline; veins yellowish on proximal half. Fourth posterior cell a little narrowed; r-m cross-vein just beyond middle of discal cell; anal cell open. Abdomen black; anterior part of second division of first segment and caudal margins of all segments very narrowly yellowish in ground color; clothed with a few white hairs and bristles laterally on proximal segments and small white hairs above. Pollen cinereous, covering side of first segment, forming antero-lateral triangles on other segments which extend from middle on anterior margin to caudo-lateral angles; inner apices of pollinose triangles connected on two-four, more widely separated on caudal segments.

*Holotype*.—Female, Carlsbad, New Mexico, June 17 (E. M. & R. H. Painter), in the collection of Dr. R. H. Painter.

### *Cophura texana* Bromley

1934. *Cophura texana* Bromley, Ann. Ent. Soc. Amer., 27: 92.

Mesonotum brown pollinose or with transversely divided lateral brown fasciae connected to middorsal one, and the middorsal fascia strongly widened anteriorly. Legs black with about proximal half of tibiae reddish. Wings hyaline with flavescence on distal half; veins brown. Abdomen largely shining black above, the anterior margin of each segment dark brown pollinose; each side with a continuous cinereous pollinose stripe. Length, 7–10 mm.

*Types*.—Holotype, male, and allotype, female, Comfort, Texas (July) at the Texas Agricultural Experiment Station.

The author has found this species in the Wichita Mts., at Craterville, Oklahoma (July), associated with *Holopogon texanus* Bromley. Specimens are also at hand from Brownwood, Texas (June).

### ***Cophura arizonensis* (Schaeffer)**

1916. *Lasiopogon arizonensis* Schaeffer, Jour. N. Y. Ent. Soc., 24: 65.

1935. *Buckellia drakei* Pritchard, Amer. Mus. Nov., no. 813: 6. New synonymy.

Black; cinereous and brown pollinose. Mesonotum with bristles white or in part brown; dorsocentrals postsutural only; scutellum with one or two pairs of marginal bristles. Legs black, yellowish to a variable extent on proximal two-thirds of anterior tibiae and proximal third of middle tibiae. Wings hyaline. Abdomen cinereous pollinose with dorsal dark brown fasciae over proximal two-thirds of each segment. Length, 6–11 mm.

*Types*.—Of *arizonensis*, one male, Huachuca Mts., Arizona, in the U. S. National Museum; of *drakei*, one male, Oracle, Arizona (August), in the American Museum of Natural History.

Schaeffer's type has been examined. Numerous specimens are at hand from Globe, Mustang Mt., Santa Rita Mts., Cochise Co., Huachuca, and Patagonia, Arizona (July 27–August). Mr. Wilcox, who has monographed the genus *Lasiopogon*, first suggested the synonymy. *Lasiopogon* Loew, under which genus Schaeffer described the species, is closely related to the genera *Stichopogon* Loew and *Willistonina* Back, and quite remote from *Cophura*; however, there is a superficial resemblance in this case.

### ***Cophura cora*, new species**

Black, cinereous and ochreous-brown pollinose; vestiture entirely pale; legs black, the tibiae largely yellow; wings hyaline; abdomen fasciate. Length, 6–8 mm.

*Male*.—Head white pollinose. Mystax white, composed of oral bristles and a few long hairs above on lower two-thirds of face. Ocellar tubercle with four yellow bristles. Antennae with proximal two segments subequal, clothed with white hairs and bristles; first segment below with several bristles as long as length of the segment; second segment below with long bristle as long as proximal two segments combined, on basal half laterally compressed; style slightly longer than second segment. Thorax cinereous pollinose, with suffused dorsal vittae ochreous pollinose. Mesonotum clothed with short yellowish and white hairs; dorsocentrals yellowish, extending well in front of transverse suture. Scutellum cinereous pollinose, marginally tinged with yellowish-brown; with two long, yellowish marginal bristles and several short white hairs on either side of disc. Legs with femora shining black, with appressed white hairs and a few white bristles; tibiae with anterior two pairs yellowish except for brownish suffusion at very tip; posterior pair yellowish only on basal fourth; tarsi black. Wings hyaline; r-m cross-vein just before middle of discal cell; anal cell open. Abdomen cinereous pollinose, with a broad brownish fascia on anterior two-thirds of each segment; conspicuously clothed with short pale hairs, longer on sides of first three segments.



*Female*.—Similar; seventh and eighth abdominal segments shining black.

*Holotype*.—Male, Tehuacan, Puebla, Mexico, July 12, 1935 (A. E. Pritchard), at the University of Minnesota. *Allotype*.—Female, Tehuacan, Puebla, Mexico, July 12, 1935 (A. E. Pritchard), at the University of Minnesota.

*Paratypes*.—Eighteen males, seven females, Tehuacan, Puebla, Mexico, July 12, 1935 (A. E. Pritchard), in the writer's collection.

Allied to *arizonensis* (Schaeffer) from which it may be distinguished by the yellow anterior four tibiae, yellow base of hind tibiae; presence of presutural dorsocentrals; ochreous-brown pollinose fasciae on the abdomen; and smaller size.

### *Cophura igualae*, new species

Black, cinereous and dark brown pollinose; vestiture pale except for mesothoracic bristles; legs black; wings hyaline; abdomen fasciate. Length, 6–8 mm.

*Male*.—Head white pollinose. Mystax white, extending nearly to antennae; composed of oral bristles and long hairs above, with shorter hairs on upper half. Ocellar tubercle with four yellow bristles and several shorter white hairs. Second antennal segment slightly shorter than first; hairs below on first segment about equal in length to bristle below on second; third segment twice as long as proximal two combined, laterally compressed on proximal half; style slightly longer than second segment. Thorax cinereous pollinose. Mesonotum thinly clothed with short, mostly brown hairs; bristles black; dorsocentrals extending nearly to anterior margin. Scutellum entirely cinereous pollinose; with several short white hairs on either side of disc; with two strong, black marginal bristles. Legs black, with white hairs and bristles. Wings hyaline; r-m cross-vein before middle of discal cell; anal cell open. Abdomen cinereous pollinose, with a dorsal dark brown fascia on each segment which covers anterior half at side, and is narrowed to anterior third in center; clothed with mostly brown short hairs above, and with white hairs laterally which are longer on first three segments. Genital armature black, clothed with long, white hairs.

*Female*.—Similar; eighth, seventh, and median line on sixth abdominal segments shining black.

*Holotype*.—Male, Iguala, Guerrero, Mexico, June 30, 1935 (A. E. Pritchard), at the University of Minnesota. *Allotype*.—Female, Iguala, Guerrero, Mexico, June 30, 1935 (A. E. Pritchard), at the University of Minnesota.

*Paratypes*.—Nine males, eight females, Iguala, Guerrero, Mexico, June 30, 1935 (A. E. Pritchard), in the writer's collection.

Related to *arizonensis* (Schaeffer) from which it differs in having the mesonotal and scutellar bristles always black; strong presutural dorsocentrals; legs always black; abdominal brown fasciae narrower and medially constricted; and male genitalia clothed with long white hairs.

Found in association with *Psilocurus caudatus* Williston and *Triclis argentifacies* Williston, all three being ground inhabiting species.

***Cophura atypa*, new species**

Black; cinereous and brown pollinose; legs with anterior four femora and often posterior ones yellowish behind; anterior four tibiae yellowish; wings hyaline; abdomen dark brown fasciate. Length, 6–9 mm.

*Male*.—Head with pollen white, on vertex and front brownish. Mystax white, over face to antennae, composed of bristles on lower third and shorter hairs above. Ocellar tubercle with six brown bristles. Proximal two antennal segments subequal, the bristles below on both segments brownish, equal in length to that of the two segments combined; third segment twice as long as proximal two together, laterally compressed; style a little longer than second segment. Thoracic pleura cinereous pollinose. Mesonotum largely brown pollinose due to the wide vittae; clothed with short brown hairs and usual long black bristles; dorsocentrals with three pairs presutural. Scutellum entirely cinereous pollinose; with several small white hairs on either side of disc and a pair of strong black marginal bristles. Legs clothed with white hairs and bristles. Anterior two pairs with femora black, behind and above yellowish; tibiae yellowish; tarsi brownish. Posterior pair black, the femora behind narrowly yellowish especially at distal end. Wings hyaline, the distal third washed with gray; cross-vein r-m at proximal third of discal cell; anal cell open. Abdomen cinereous pollinose with dorsal dark brown fasciae, each fascia covering the posterior margin of one segment, extending over following one covering half of the segment at the middle and fully two-thirds of it at the side. Genital armature black with long white pile.

*Female*.—Similar; anterior four femora yellowish only behind; middle tibiae dark underneath; abdominal tergites eight, seven, and median line of six shining black.

*Holotype*.—Male, Tehuacan, Puebla, Mexico, July 12, 1935 (A. E. Pritchard), at the University of Minnesota. *Allotype*.—Female, Tehuacan, Puebla, Mexico, July 12, 1935 (A. E. Pritchard), at the University of Minnesota.

*Paratypes*.—Two males, Tehuacan, Puebla, Mexico, July 12, 1935 (A. E. Pritchard); two males, one female, Chilpancingo, Guerrero, Mexico, June 28, 1935 (A. E. Pritchard); two males, one female, Iguala, Guerrero, Mexico, June 30, 1935 (A. E. Pritchard); in the author's collection.

Related to *arizonensis* (Schaeffer) from which it differs in having the mesonotal and scutellar bristles all black; presutural dorsocentrals present; legs with femora and tibiae of anterior two pairs largely yellowish; abdominal dark fasciae constricted medially; and male genitalia long pilose.

***Cophura apotma*, new species**

Black; cinereous and rich brown pollinose; legs with middle femora behind and ends of other femora, anterior four tibiae and base of hind tibiae all castaneous; abdomen rich brown pollinose above with dark brown dorsolateral spots. Length, 6–9 mm.

*Male*.—Head white pollinose, the vertex tinged with brown. Mystax white, with mostly oral bristles and rather long hairs above to antennae. Ocellar tubercle with six brown bristles. First antennal segment slightly longer than second, with bristles below as long as the segment; second with bristles below as long as proximal two segments combined; third twice as long as basal two together, laterally compressed; style a little longer than second segment. Thoracic pleura cinereous pollinose with brownish tinges. Mesonotum brown pollinose with the three vittae wide, bare of pollen; clothed with short brown hairs and the usual bristles which are yellowish or brownish; five pairs of presutural dorsocentrals. Scutellum brown pollinose with two pairs of yellowish marginal bristles. Legs black in part, castaneous on ends of femora, broad posterior side of middle femora, anterior four tibiae, and narrow base of hind tibiae; clothed with white hairs and bristles. Wings hyaline, lightly tinged with flavescence on distal half; r-m cross-vein just beyond middle of discal cell; anal cell open. Abdomen rich brown pollinose; dark brown spots on anterior two-thirds of each segment on dorso-lateral portion; cinereous pollinose narrowly on lateral margins, widening caudally on each segment to area behind dark spot; clothed with short brown hairs and longer yellowish hairs on sides of proximal two segments. Genitalia with rather short pale hairs.

*Female*.—Similar; posterior femora behind and part of anterior femora behind reddish; caudal margins of abdominal tergites six and seven and all of eight bare of pollen and shining.

*Holotype*.—Male, Tehuacan, Puebla, Mexico, July 12, 1935 (A. E. Pritchard), at the University of Minnesota. *Allotype*.—Female, Tehuacan, Puebla, Mexico, July 12, 1935 (A. E. Pritchard), in the author's collection.

Related to *arizonensis* (Schaeffer) from which it differs in having presutural dorsocentrals; mesonotal vittae largely bare of pollen; femora in part and anterior four tibiae reddish; and abdomen rich brown pollinose above.

*Apotma* and the related Mexican species having the anterior calli of the mesonotum bristly, and probably *arizonensis*, occur on the ground; the other species of the FUR GROUP occur aerially upon the tips of dead twigs.

### ***Cophura acapulcae*, new species**

Black; cinereous and brown pollinose. Mesonotum dark brown pollinose; legs black; wings gray; abdomen dark brown pollinose above or with narrow caudal margin lighter. Length, 8–11 mm.

*Male*.—Face and front ochreous-brown pollinose; vertex brown pollinose; rear of head cinereous pollinose. Mystax white, a thin row of oral bristles and several short hairs above. Bristles on ocellar tubercle and proximal two antennal segments brownish. Second antennal segment three-fourths length of first; third hardly twice as long as proximal two combined; style slightly longer than second segment. Thoracic pleura cinereous pollinose, brownish above. Mesonotum dark brown pollinose except posteriorly and along suture

on either side of middorsal vitta; very scantily clothed with short brown hairs, three black bristles on each side, and two pairs of yellowish dorsocentrals. Scutellum entirely cinereous pollinose, without hairs or bristles. Legs black, with whitish hairs and very few bristles; anterior tibiae below with rather dense, long silky hair. Wings smoky gray; r-m cross-vein near middle of discal cell; anal cell open. Abdomen dark brown pollinose above, cinereous pollinose on sides and on caudal two segments; practically without hairs and bristles. Genital armature brown haired.

*Female*.—Similar; fascia just before caudal margin of each segment lighter, nearly cinereous pollinose; segments eight, seven, and caudal margin of six shining black.

*Holotype*.—Male, Acapulco, Guerrero, Mexico, June 11, 1935 (A. E. Pritchard), at the University of Minnesota. *Allotype*.—Female, Acapulco, Guerrero, Mexico, June 11, 1935 (A. E. Pritchard), at the University of Minnesota.

*Paratypes*.—Seventy-five males, twenty-five females, Acapulco, Guerrero, Mexico, June 9–18, 1935 (A. E. Pritchard), in the writer's collection.

Differs from all other species of *Cophura* except the following one in lacking scutellar hairs and bristles on the margin. Related to *hesperia* which has the tibiae largely reddish. One male had a winged termite as prey.

#### ***Cophura calla*, new species**

Black; brown and dark brown pollinose; with whitish to brownish vestiture. Legs black with about proximal half of tibiae reddish; wings brown-flavescens; abdomen with dark brown fasciae. Length, 9–12 mm.

*Male*.—Face ochreous pollinose; front, vertex, and upper occiput brown pollinose; rear of head otherwise cinereous. Mystax whitish, with mostly oral bristles and shorter hairs above nearly to antennae. Ocellar tubercle and first two antennal segments with brownish bristles. Second antennal segment three-fourths length of first; third twice as long as proximal two combined, tapering distally as seen from the side, compressed near base as seen from above; style slightly longer than second segment. Thoracic pleura cinereous-brown pollinose. Mesonotum brown pollinose with three wide vittae bare of pollen; clothed with brown setae and brownish bristles; without dorsocentrals. Scutellum brown pollinose, with several small brown discal setae, without marginal hairs or bristles. Legs black, tibiae reddish on about proximal half of anterior pair, about proximal two-thirds of posterior two pairs; clothed with whitish hairs and bristles and long hairs below on anterior tibiae. Wings brown-flavescens, especially on costal side of distal half; cross-vein r-m just beyond middle of discal cell; anal cell open. Abdomen brown pollinose with a medially constricted dark brown fascia on proximal half of segments two to five; seven and eight bare above; clothed with brown hairs and longer whitish hairs on sides of one and two. Genitalia with yellowish hairs.

*Female*.—Similar; abdominal segments eight, seven, six, and caudal margin of five shining black.

*Holotype*.—Male, Iguala, Guerrero, Mexico, June 30, 1935 (A. E. Pritchard), at the University of Minnesota. *Allotype*.—Female, Iguala, Guerrero, Mexico, June 30, 1935 (A. E. Pritchard), at the University of Minnesota.

*Paratypes*.—Twenty males, eighteen females, Iguala, Guerrero, Mexico, June 30, 1935 (A. E. Pritchard), in the writer's collection.

Related to *acapulcae* from which it differs in having the dorsocentrals lacking; tibiae reddish on proximal half; wings brownish; and abdomen rich brown pollinose with medially constricted dark brown fasciae on proximal half of the segments. Superficially resembles *zandra* very much.

### ***Cophura stylosa* Curran**

1931. *Cophura stylosa* Curran, Amer. Mus. Nov., 487: 7.

1935. *Buckellia stylosa* Pritchard, Amer. Mus. Nov., 813: 6.

A light cinereous pollinose species with three bare, black mesonotal vittae; wings hyaline; femora usually reddish on ends and behind; and tibiae reddish except distal fifth. The antennal style is often as long as proximal two segments combined. Length, 8.5–12 mm.

*Types*.—One female from Woods Co., Oklahoma (July), in the American Museum of Natural History.

Specimens are at hand from Boise City, Oklahoma (July); Clarke Co., Kansas (June); Kiowa Co., Colorado (August 19); and Sweetwater, Texas (June 15).

### ***Cophura pollinosa* Curran**

1930. *Cophura pollinosa* Curran, Amer. Mus. Nov., 415: 10.

1935. *Buckellia pollinosa* Pritchard, Amer. Mus. Nov., 813: 7.

A cinereous and light brownish pollinose species with brownish mesonotal vittae usually partially rubbed off; wings hyaline; femora black; tibiae reddish on proximal half to two-thirds; abdomen with light brownish fasciae which are often quite broad. Length, 7–10 mm.

*Types*.—Described from Baboquivari Mts. and Coyote Mts., Arizona (August), in the American Museum of Natural History.

Material is at hand from Tucson, Sells, Tubac, and Pima Co., Arizona, all taken in August. A female from Tucson, taken in May, is larger and has the abdomen largely brown pollinose dorsally with the segmental posterior margins yellowish in ground color; this may represent another species.

### ***Cophura hesperia* (Pritchard)**

1935. *Buckellia hesperia* Pritchard, Amer. Mus. Nov., 813: 7.

Cinereous and brown pollinose; mesonotal vittae entirely brown pollinose, the median stripe geminate; wings flavescent on distal half; femora black, tibiae reddish except distal fourth; abdomen with dorsum dark brown pollinose, laterally cinereous pollinose. Length, 8–10 mm.

*Types*.—Two males and two females, Tucson, Arizona (August);

holotype and allotype in the American Museum of Natural History. Known only from type material.

***Cophura vera* (Pritchard)**

1935. *Buckellia vera* Pritchard, Amer. Mus. Nov., 813: 8.

Cinereous and brown pollinose; mesonotal vittae wide, brown pollinose; wings tinged with brownish on distal half; femora black; anterior tibiae black; middle tibiae reddish on proximal half; posterior tibiae reddish on proximal three-fourths; abdomen dark brown pollinose above, cinereous pollinose laterally. Length, 7–8 mm.

*Types*.—Described from two females, Tuscon, Arizona (August); holotype in the American Museum of Natural History.

A male is at hand from Cobabi Mts., Arizona (September), and is quite similar to the female.

***Cophura lutzi* Curran**

1931. *Cophura lutzi* Curran, Amer. Mus. Nov., 487: 7.

1934. *Cophura lutzi* Bromley, Ann. Ent. Soc. Amer., 27: 102.

1935. *Buckellia lutzi* Pritchard, Amer. Mus. Nov., 813: 7.

1941. *Cophura lutzi* James, Jour. Kans. Ent. Soc., 14: 33.

Cinereous and brown pollinose; two or three pairs of marginal scutellars; wings hyaline or tinged with brown; femora black; anterior four tibiae yellowish on proximal three-fourths; posterior tibiae yellowish on proximal two-thirds; abdomen cinereous pollinose dorsally, with a faint brownish tinge. Genitalia black. Length, 7.5 mm.

*Types*.—Described from a single male, Regnier, Colorado (August); in the American Museum of Natural History.

The diagnosis of *lutzi* is taken from the type. The third pair of scutellars are weakly developed. Material examined includes three males, four females, Hidalgo Co. and Weslaco Co., Texas (June); four females, Mountain Park and Alamogordo, New Mexico (June); and one female, Kits Peak, Rincon, Baboquivari Mts., Arizona (Aug. 1–4). These specimens compare well with the type, although the New Mexico specimens have the tibiae more extensively blackened. One male, Chinati Mts., Texas, and one male, Otero Co., New Mexico (June), have the abdomen rich brown pollinose above; these may represent a new species.

***Cophura lutzi* var. *wilcoxi* (Pritchard)**

1935. *Buckellia wilcoxi* Pritchard, Amer. Mus. Nov., 813: 8.

Cinereous and light brown pollinose; two or three pairs of marginal scutellars; wings hyaline or tinged with brown; anterior four tibiae yellowish on proximal three-fourths, posterior tibiae yellowish on proximal half; abdomen cinereous with brown fasciae. Length, 8–9 mm.

*Types*.—Male and female, Kenton, Oklahoma (June), in the American Museum of Natural History.

Additional material is necessary to show whether this form merits recognition or not.

## BREVICORNIS GROUP

Differs from the FUR GROUP by having the face well rounded, receding orally, and from all the groups by having the mesonotum clothed with very short bristles and the abdomen finely punctate. The species all agree in having the body black, and the abdominal tergum with anterior margin and caudo-lateral angles white pollinose.

*Cophura brevicornis* (Williston)

1884. *Taracticus brevicornis* Williston, Trans. Amer. Ent. Soc., 11: 22.  
 1885. *Aphamartania brevicornis* Williston, Trans. Amer. Ent. Soc., 12: 54.  
 1909. ?*Cophura brevicornis* Back, Trans. Amer. Ent. Soc., 35: 380.  
 1923. *Cophura brevicornis* Melander, Psyche, 30: 210.  
 1941. *Buckellia brevicornis* James, Trans. Kans. Ent. Soc., 14: 33.

*Types*.—Described from one male and one female, Washington Territory; at the University of Kansas.

One male, Manitou Park, Colorado (F. H. Snow), in the University of Kansas collection incorrectly bears a red label similar to the types. Material studied from Washington was from the following localities: Virden (July); Knightmore (Aug.); Wolf Fork, Touchet River (July); Tacoma (August); Puyallup (July, August); Rainier National Forest (July); Quilcene (Aug.); Wawawai (July). Material studied from Oregon was from the following localities: LaGrande (July); Cascadi (August); Newport (Sept. 7); Hood River; Strawberry Mtn., Grant Co., elev. 8,600 ft. (Aug.). One male was collected at Smith River, California (July). Colorado material was collected at Boulder (July). One male was taken at Monroe Canon, Sioux Co., Nebraska. All thirty-three of these specimens agree in having the legs castaneous.

*Cophura brevicornis* var. *melanochaeta* Melander

1923. *Cophura melanochaeta* Melander, Psyche, 30: 210.

Differs from *brevicornis* only in having the legs black.

*Types*.—Described from one pair, Waha, Idaho (August), and one female Moscow Mt., Idaho (July), probably in Dr. A. L. Melander's collection.

Material examined includes one female, Hamilton, Montana (July); two males, one female, San Antonio Canyons, California (Aug.). These specimens have the legs black. One female, Bishop, California (July), has the legs black, but the abdomen is dark reddish. Three males, two females, Laguna Mts., California (July), have the femora black to dark brownish, the tibiae dark chestnut to castaneous. One male, Lake Tahoe, California (July), has the legs dark castaneous, the fore femora blackish, and might well represent either *melanochaeta* or *brevicornis*. It is quite likely that *melanochaeta* is not worthy of recognition.

*Cophura caca*, new species

Black; with cinereous pollinose markings. Legs black; abdomen with anterior line above and caudo-lateral spots on each segment whitish pollinose. Length, 8–10 mm.

*Male*.—Head cinereous pollinose. Face evenly convex, as seen from the side, projecting beyond the eyes by a distance as long as

first antennal segment. Mystax composed of several mixed rows of oral black bristles and a few white hairs on lower half of face. Bristles of ocellar tubercle, front, and proximal two antennal segments all black. First antennal segment with two bristles below equal in length to that below second; second segment two-thirds length of first; third not quite two and one-half times length of basal two combined; style as long as first antennal segment. Thoracic pleura cinereous pollinose; metapleura with bristles all white. Mesonotum with lateral and geminate middorsal stripes bare, with transverse aciculations; light cinereous pollinose around disc; clothed with stout black setae and five lateral bristles on each side; dorsocentrals undifferentiated. Scutellum with transverse impression near base; covered except on broad caudal margin with cinereous pollen; with several very small marginal setae. Legs jet black; femora transversely striate, clothed with white appressed hairs and black bristles; the slender bristles below on anterior tibiae white; tarsi with vestiture black. Wings nearly hyaline, lightly washed with grayish-brown; r-m cross-vein at two-thirds length of discal cell; anal cell open. Abdomen black, punctate, with black setae in the puncta; lateral bristles of first abdominal segment all white; tergites two to five with anterior margin and caudo-lateral spots whitish pollinose. Genitalia concealed from above, with hairs mostly black.

*Female*.—Similar; with a pair of small marginal scutellars.

*Holotype*.—Male, Otero Co., New Mexico, June 20, elevation 8,000 ft. (E. M. & R. H. Painter); in the collection of Dr. R. H. Painter.

*Allotype*.—Female, Otero Co., New Mexico, June 20 (E. M. & R. H. Painter); in the collection of Dr. R. H. Painter.

*Paratype*.—Four males, seven females, Otero Co., New Mexico, June 20 (E. M. & R. H. Painter).

Related to *brevicornis* from which species it may be distinguished by having the tibial hairs white and by being larger in size.

### ALBOSETOSA GROUP

The face is decidedly and evenly convex, receding orally, a condition closely approximated in *BREVICORNIS*. Otherwise from this there is no good character which will separate this group from all other groups. The shining black abdomen, convex above, marked only with caudo-lateral cinereous pollinose spots on each segment is characteristic of the group. Williston, Cole, and Curran have remarked on the similarity of appearance of the species to some of those of the genus *Cyrtopogon* Loew.

### *Cophura scitula* (Williston)

1884. ? *Nicocles scitulus* Williston, Trans. Amer. Ent. Soc., 11: 19, pl. 2, figs. 1, 1a.

1885. *Aphamartania scitulus* Williston, Trans. Amer. Ent. Soc., 12: 54.

1901. *Cophura scitula* Williston, Biol. Centr.-Amer., Dipt. 1, suppl.: 314.

1909. *Cophura scitula* Back., Trans. Amer. Ent. Soc., 35: 382.

1923. *Cophura scitula* Melander, Psyche, 30: 210.

*Types*.—Described from a female from Washington Territory, which is at the University of Kansas.



Melander further lists the species from Portland, Oregon. A male and female, Smith River, Douglas Co., Oregon (Sept.); and a female, presumably from the Northwest (July), are referred to this species. The type is described as 5.5 mm. long, and has the cross-veins and furcations flavescent. The specimens at hand are 9–10 mm. long, and have all the veins broadly clouded with brown. More collecting is necessary to show the exact status of this and the following species with regard to variation and synonymy. There is no character of value in the color of the mystax as used in the keys by Melander and Curran.

### *Cophura albosetosa* Hine

1908. *Cophura albosetosa* Hine, *Canad. Ent.*, 40: 202.  
 1919. *Cophura cyrtopogona* Cole, *Proc. Calif. Acad.*, 9: 236.  
 1923. *Cophura albosetosa* Melander, *Psyche*, 30: 209.  
 1925. *Buckellia albosetosa* Curran, *Canad. Ent.*, 57: 156.

*Types*.—Of *albosetosa*, two males, one female, Hope Mts., B. C. (July), and one female, Similkameen, B. C. (July), probably at the Ohio State Museum; of *cyrtopogona*, one male and one female, Hood River Valley, Oregon (August), in the California Academy of Sciences.

*Albosetosa* was described as being 7–9 mm. long, and as having the wings "uniformly very dilute brownish, so dilute, in fact, that they might well be said to be hyaline." *Cyrtopogona* was described as being 6 mm. long, with hyaline wings. Melander further listed *albosetosa* from Yakima, Washington, considering *cyrtopogona* to be a synonym. A male, Mt. Rainier, Washington (Sept.); a male Merritt, B. C. (Aug.); and a female, Mt. Rainier, Washington (July), are referred to this species. These specimens are 7–8 mm. long, with the wings hyaline in the female; costal cell brown and veins proximally bordered with brown in the male. Curran recorded *albosetosa* from Revelstoke, B. C.

### *Cophura vitripennis* (Curran)

1927. *Buckellia vitripennis* Curran, *Canad. Ent.*, 59: 85.

*Types*.—Male, Lillooet, B. C. (June), in the Canadian National Collection. Known only from the type specimen.

The key and group characters should serve for easy recognition of this species.

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A REVISION OF THE NORTH AMERICAN SPECIES OF BUPRESTID BEETLES BELONGING TO THE TRIBE CHRYSOBOTHRINI, by W. S. FISHER. 1942. Pages 275; 109 text figures and 17 plates. Published by U. S. Dept. Agri., Misc. Pub. 470.

This revision of the North American *Actenodes* and *Chrysobothris* is quite welcome.

Since Horn's monograph of the latter genus in 1886, many new species have been described. The author has straightened out the confusion which existed in regard to names and seven new species are described. Four distinct species are recognized in the *Chrysobothris femorata* complex. It is possible that past records of degrees of damage caused by the flatheaded apple tree borer in various parts of the country may now be accounted for.

Keys are given for both males and females as far as material permitted. All species are completely described and character differences in sexes are noted. Wherever possible descriptions are drawn from type specimens. Both surfaces of the male genitalia as well as last visible sternites of both sexes, clypei and anterior tibiae of the males are figured.

This complete, well illustrated paper will be a great aid to those of us working on Coleoptera.—J. N. KNOLL.

# THE AMERICAN SPECIES OF RHOPALOSOMA

CHARLES T. BRUES,

Biological Laboratories, Harvard University

The genus *Rhopalosoma* was first described by Cresson in 1865 with a Cuban species, *R. poeyi* as the genotype. Cresson regarded it as an aberrant member of the Ichneumonidae. Several years later, in 1868, Westwood published an account of a similar insect from Hayti to which he gave the name *Sibyllina aenigmatica*, placing it among the aculeate Hymenoptera and suggesting that it is related to the Vespidae although not dissimilar to certain Sphecidae (Pelopoeus), and in the male even resembling an ant. In his "Thesaurus Entomologicus Oxoniensis" Westwood later (1874) gives a much fuller account of his views on the relationships of *Rhopalosoma* which he then recognized as a prior name for his own genus *Sibyllina*. He refers there also to the views of Cresson and Frederick Smith (1868) who agreed that it was related to the Ichneumonidae. He notes that the late Mr. Haliday had earlier attached to the type specimen a note that he regarded it as related to Pelopaeus. I shall not repeat the several arguments indulged in by these earlier entomologists, as they are reviewed by Westwood (1874).

The question of the systematic affinities of *Rhopalosoma* was reopened in 1896 by Ashmead who again discussed at length the views of his predecessors. He further proposed the elevation of *Rhopalosoma* to family rank and placed it as a true aculeate and "a connecting link between the Vespidae and Sapygidae." In his later classification of the Vespoidea (1903) Ashmead placed his family *Rhopalosomatidae* Vespoidea in the linear arrangement<sup>1</sup> after the Scoliidæ, Tiphidiæ and Cosilidæ and before the Thynnidæ, Myrmosidæ and Mutillidæ.

In 1910 Morley described a *Rhopalosomatid* from India and took occasion to review the matter. He differed with Ashmead as he saw no close relationship of *Rhopalosoma* to the Cosilidæ and Thynnidæ.

After the lapse of another period of years, Turner and Waterston (1917) reviewed the matter in connection with the neotropical genus *Olixon* of Cameron which they regarded as related to *Rhopalosoma*, placing both in the vicinity of the Vespidae or Eumenidæ as had been done by Westwood. They add also that the genitalia of the male indicates close affinities with the Eumenidæ which in turn differ strongly in this respect from all other Hymenoptera. Unfortunately they go no further as to the peculiarities of the Eumenidæ and *Rhopalosomatidae* and Dr. Joseph Bequaert assures me that he does not consider the Eumenidæ and Vespidae to have unusual male genitalic structures after many years of intensive study of these wasps.

The most prominent structures of the male genitalia of *Rhopalosoma* are a pair of upcurved spines which occasionally project beyond the

<sup>1</sup>The correctly formed family name, *Rhopalosomatidae*, has been used by most recent workers and should replace the contracted spelling which is not in accordance with any accepted code of nomenclature.

tip of the abdomen. These seem never to have been mentioned in the literature, probably because they are most frequently retracted within the body. When fully exerted as in one specimen before me, they are similar in form and curvature to those characteristic of the Mutillidae. They are also apparently identical with a pair that are present in the African genus, *Algoella*,<sup>2</sup> and in the Australian *Harpagocryptus* mentioned in the following paragraph, and in *Olixon*.

The present writer has referred to *Olixon* in two earlier papers (Brues, 1922 and 1926) and could not accept the views expressed by Turner and Waterston concerning its affinities with *Rhopalosoma*. His opinion might, however, possibly require revision in view of the similarly bispinose hypopygium in these two genera and the strangely similar habits of *Rhopalosoma* and *Harpagocryptus* which is obviously a relative of *Olixon*. Thus, in 1913, Hood reared *Rhopalosoma* from a larva which was parasitic externally on a species of true cricket (*Orocharis saltator*) after the manner of members of the family Dryinidae. Moreover, in the Australian *Harpagocryptus* the larva likewise forms an external sac on the side of the abdomen of crickets. Such similarities are most remarkable and cannot be disregarded in any attempt to place *Rhopalosoma* in the system.<sup>3</sup> Unfortunately *Olixon*, *Harpagocryptus*, *Algoella*, and *Nealga*, although obviously related among themselves, form a group of very different affinities that cannot be associated with the Dryinidae.<sup>4</sup>

Thus, we must still accept *Rhopalosoma* as a highly aberrant hymenopteron, forming the type of a family whose relationships cannot be determined with certainty. The African *Paniscomima* Enderlein is probably not generically distinct as its separation rests upon very slight

\*This insect was described by the writer in 1910 as *Algoa*, but as the generic name is preoccupied, Kieffer proposed *Algoella* as a substitute in 1914 (Das Tierreich, Lief. 41, p. 000). However, I strongly suspect that the wasp described by Cameron as *Apteropompilus dentatus* from Cape Colony (Zeits. Hym. u. Dipt., 1904, p. 176, ♀, and 1905, p. 136, ♂) is *Algoella heterodoxa* Brues. Cameron's description of the greatly thickened fore legs, the wingless male, the long pronotum and the dentate propodeum make it probable that the insect before him was congeneric and so far as it goes, the description agrees with *A. heterodoxa*, even to the color of the species in question. If they are identical, Cameron's specific name has priority.

<sup>2</sup>It is well known that the females of most Dryinidae have the front tarsi greatly modified to form grasping organs that presumably enable them to keep in contact with their very active hosts at the time of oviposition. It seems probable that the strangely inflated tarsi of the female *Rhopalosomatidae* have the same function, but they can in no sense be traced to a common stem as their origin and development is obviously independent. Thus their similar function and dissimilar structure seem to weigh against any association of the two families as closely related.

<sup>3</sup>Still another view, and probably the correct one, has recently been put forth by Reid (1939), who places *Olixon* in the *Psammocharidae* together with *Algoella*, *Harpagocryptus*, *Olixon*, *Nealga*. He believes that *Algoella* is very close to *Phyllosphex* (*Apteropompilus*) *dentatus* Cameron, a conclusion that I can heartily support, as noted in a preceding paragraph. There still remains the question of the strangely similar parasitic habits of *Rhopalosoma*, *Dryinus et al.*, and *Harpagocryptus*, and it is difficult to cast these aside as purely fortuitous or convergent developments. There seems to be no evidence that any of the other wingless *Psammocharidae* depart from the general habit of their relatives in preying on spiders (cf. Arnold, 1940).

characters. The Indian *Hymenochimaena* based on *Rhopalosoma abnorme* Morley is unquestionably a true *Rhopalosomatid*, very distinct from *Rhopalosoma* and perhaps the future discovery of other forms related to it may serve to clarify the systematic relationships of this very remarkable group.

The material on which the following taxonomic account is based is not large, as the insects appear never to be abundant. It includes specimens belonging to the Museum of Comparative Zoology, United States National Museum, Cornell University, the Carnegie Museum at Pittsburgh and some in my own collection. Including the single specimen of *Rhopalosoma poeyi* Cresson now preserved in the Philadelphia Academy of Sciences, I have been able to study in all 37 specimens from North America, the West Indies, Central American and South America. These represent five species, all closely related and distinguishable by slight, although I believe, sufficiently distinctive characters to warrant their separation.

### *Rhopalosoma* Cresson

1865. Cresson, Proc. Entom. Soc. Philadelphia, vol. 54, p. 58.  
 1868. Westwood, Trans. Entom. Soc. London, p. 329 (*Sibyllina*).  
 1874. Westwood, Thesaurus Entom. Oxon., p. 130.  
 1896. Ashmead, Proc. Entom. Soc. Washington, vol. 3, p. 303.  
 1910. Morley, Trans. London Entom. Soc., 1910, p. 386.  
 1926. Brues, Psyche, vol. 33, p. 19.

### KEY TO THE SPECIES OF RHOPALOSOMA

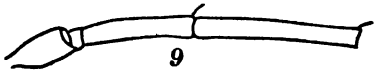
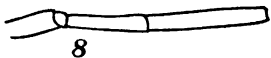
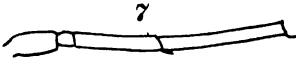
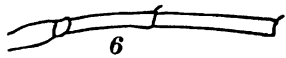
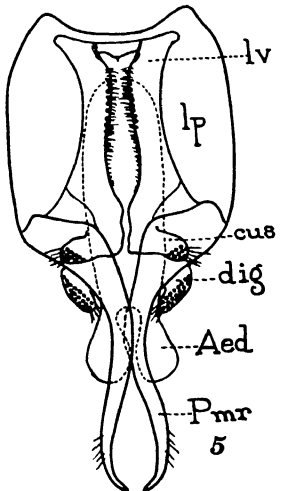
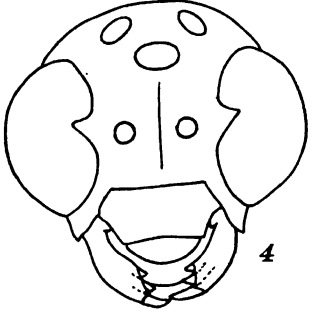
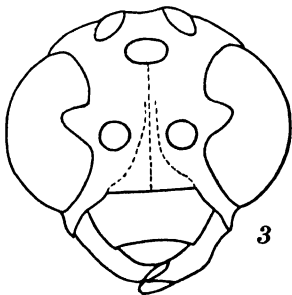
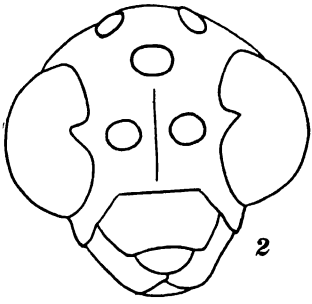
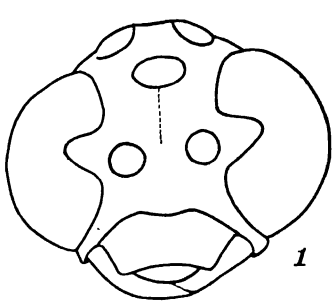
1. Eye-notch very large, approximately as deep as the width of the antennal scape (fig. 1); median ocellus wider than the distance that separates it from the eye-margin. . . . . **aeigmaticum**
- Eye-notch of moderate or small size, not deeper than the width of the first flagellar joint (figs. 2, 3, and 4); median ocellus separated from the eye-margin by at least its own width. . . . . 2
2. Flagellum of antennae entirely pale ferruginous or fulvous, concolorous with the body. . . . . 3
- Flagellum of antennae darker, entirely black above. . . . . 4
3. Eye-notch of moderate size (as in fig. 3). . . . . **poeyi**
- Eye-notch small (fig. 2). . . . . **nearcticum**
4. Eye-notch of moderate size (fig. 3). . . . . **bolivianum**
- Eye-notch small (fig. 4). . . . . **simile**

The species of *Rhopalosoma* are all rather large, wasp-like insects of pale brownish color with long, slender legs and large hyaline wings.

### EXPLANATION OF PLATE I

Fig. 1. Head of *Rhopalosoma aeigmaticum* Westw., frontal view, with antennae not shown. 2. Head of *Rhopalosoma nearcticum* sp. nov. 3. Head of *Rhopalosoma boliviense* sp. nov. 4. Head of *Rhopalosoma simile* sp. nov. 5. Male genitalia of *Rhopalosoma nearcticum* in dorsal view. Aed., aedeagus; cus., cuspis volsellaris; dig., digitus volsellaris; lp., lamina parameralis; lv., lamina vosellaris; Pmr., paramera. 6. Basal segments of antenna of *Rhopalosoma aeigmaticum*. 7. Basal segments of antenna of *Rhopalosoma nearcticum*. 8. Basal segments of antenna of *Rhopalosoma bolivianum*. 9. Basal segments of antenna of *Rhopalosoma simile*.

The figures are from camera lucida drawings made by Mrs. A. S. O'Connor.



The head is more or less lenticular, about twice as wide as long in vertical view and about as high as wide in frontal view. Eyes moderately large, very strongly convex and with their inner margin deeply emarginate next to the insertion of the antennae. Ocelli very large in both sexes. Clypeus large, broad, convex, its anterior margin straight; deeply separated from the front. Labrum triangular, twice as broad as long. Mandibles large and strong, armed with three teeth at apex, the inner tooth smallest and the outer one much the largest. Maxillary palpi much longer than the head; basal segment short, second longer, swollen; third and fourth longer, growing much more slender; fifth longest, very thin. Antennae long and slender, slightly geniculate; scape short and thick; pedicel very small, transverse; segments of flagellum cylindrical, each bearing a pair of short, thin spines at apex; first segment much the shortest; second and following about equal, the segments becoming extremely slender toward the tip of the antennae. Male with 13 and female with 12 antennal segments. Thorax slender, posterior angles of pronotum reaching to the tegulae; mesonotum as broad as long, with parallel parapsidal furrows that are complete behind, but do not extend to the anterior border of the mesonotum. Propodeum long, smooth, gradually declivous behind, the abdomen attached to its tip just beyond the insertion of the hind coxae. Legs long and slender; anterior femora strongly thickened basally in the female, in which sex the second to fourth tarsal segments are greatly flattened, expanded laterally and trifid apically with the projections connected by a thin, transparent membrane, Tarsi of male very slender, simple. Tarsal claws of female long, stout, sharply hooked at the tip and with a small subapical tooth; the claws bear also a number of stout, bristly hairs. Tarsal claws of male similar, but minute and more slender. The trochanters appear to be two-segmented, but the second segment is really a part of the femur rather than of the trochanter as it is ankylosed with the former at least in the hind legs. Wing venation rather unusual. Fore wing with no costal cell; stigma narrow, linear; radial cell long and narrow; basal vein long and sloping, almost parallel with the long first recurrent nervure; basal two sections of cubitus very thin and delicate as are also the transverse cubiti, the cubitus arising well below the base of the basal vein; second recurrent nervure very faintly indicated, nearly interstitial with the second transverse cubitus; nervulus strongly postfurcal; first discoidal cell very large, fully five times as long as high. Hind wing with a double anal lobe formed by two deep incisions; radiellian cell broad externally. Abdomen with a long cylindrical petiole, which is very slender at the base and gradually swollen near apex, its spiracles placed just before the middle; second tergite long, third shorter, fourth very short, fifth and sixth longer. Sting terminal; male with a pair of slender, upcurved spines at the tip of the abdomen, which are not always extruded.

***Rhopalosoma aenigmaticum* Westwood**1868. Westwood, Trans. Entom. Soc. London, p. 329 (*Sibyllina*).

1874. Westwood, Thesaur. Entom. Oxon., p. 130, Pl. 24, fig. 9.

*Female*.—Length 11 mm. Pale testaceous or luteous, without any distinct darker markings or stains, except the area between the ocelli and tips of the mandibles which are black; antennae entirely pale. Ocelli very large, the width of the median ocellus clearly greater than its distance from the eye-margin or from the posterior ocelli. Emargination of inner margin of eye very large and deep, its depth equal to the greatest thickness of the scape of the antennae; its inner margin rounded, not at all angulate. Head in dorsal view twice as wide as long, the occiput rather feebly and weakly narrowed medially; in frontal view the head is seven-eighths as high as wide, measuring from the vertex to the lower margin of the clypeus. Upper portions of head entirely smooth, but not at all highly polished. Sides of face below very faintly pilose, clypeus distinctly so, with a fringe of long hairs along its anterior margin; the labrum densely pilose. Second flagellar segment one-half longer than the first; third equal to the second; following segments gradually but very slightly shorter and much more slender toward the tip of the antennae. Thorax clothed with very short but quite dense pile. Parapsidal furrows narrow, but sharply defined, not extending in front of the anterior third of the mesonotum. Petiole of abdomen slightly less than five times as long as high at its thickest portion where it is as wide as high.

*Male*.—Somewhat smaller and more slender, but essentially similar.

The description given above is drawn up from a single male and female from Manneville, Hayti, collected by Dr. William M. Mann.

Another pair from the same locality collected during February, 1922, are in the collection of the American Museum of Natural History. The male is very small (8 mm.), and is apparently a depauperate specimen with the ocelli abnormally small.

I have assumed that these specimens are conspecific with Westwood's types which were from Hayti, although it has been impossible to compare them. Naturally Westwood thought the Haytian form was identical with Cresson's species from Cuba as there was no reason to believe that *Rhopalosoma* included more than a single species.

***Rhopalosoma poeyi* Cresson**

1865. Cresson, Proc. Entom. Soc. Philadelphia, vol. 4, p. 59.

I have examined a single female from the series of three females and two males that were used by Cresson for his original description. This is in the collection of the Philadelphia Academy and is apparently the only example of the type series remaining. It is very similar to the other species, but I think definitely distinct on the basis of the characters cited in the foregoing key. Apparently it has not been collected since its original discovery in Cuba by Gundlach, and like the other members of the genus, appears to be a rare insect.



***Rhopalosoma nearcticum* sp. nov.**

*Female*.—Length 13.5–17.0 mm. Color pale fulvo-ferruginous, the space between the ocelli and the tips of the mandibles blackened; antennae not darkened on the flagellum; abdomen rarely slightly darker toward the apex. Width of median ocellus very distinctly less than the distance that separates it from the eye margin and about equal to its distance from either of the posterior ocelli. Emargination of inner margin of eye comparatively small, more triangulate and angular than usual. Head in dorsal view twice as wide as long, the occiput sharply narrowed medially; in frontal view seven-ninths as high as wide, measuring from the vertex to the lower margin of the clypeus. Upper parts of head practically bare and impunctate; sides of face below pilose with very minute hairs; the lower margin of the clypeus fringed with much longer fulvous hairs; labrum densely clothed with similar hairs. Antennae showing no distinctive specific characters. Second flagellar segment one-half longer than the first, or barely less; second and third equal, each slightly but distinctly longer than the fourth; following segments growing gradually shorter and more slender to the tip of the antenna which is extremely thin. Pilosity of thorax very short and sparse, white, visible only in certain lights. Parapsidal furrows very clearly impressed, narrow, smooth, slightly bowed outwards at the middle and not extending in front of the anterior fourth of the mesonotum. Petiole of abdomen slightly more than five times as long as high at its thickest portion where it is as wide as high.

Type ♀ from Kissimmee, Florida, (Nathan Banks Collection), in the Museum of Comparative Zoology. I have seen also numerous specimens of both sexes, all from various parts of Florida, as indicated below; Seminole Co., Fla., June 9–July 18, 1929 (M. M. Brunk, H. Clark, B. D. Hiers, Jr., C. Nelson); Hillsboro Co., Fla., June 16 (M. M. Brunk); Orange Co., Fla., July 7–16, 1929 (B. L. Smith and E. Storrs); all of these in the U. S. National Museum; Fort Mead, Fla., August 13, 1920 (P. W. Oman), in the University of Kansas Museum; Gulfport, Fla., June (Reynolds), in the Museum of Comparative Zoology and the Cornell University Museum; Plummer's Island, Md. (J. D. Hood); Berlin, Md. (F. C. Bishopp); and St. Augustine, Fla. (Ashmead Collection), in the U. S. National Museum. Other records of *Rhopalosoma* from the Southeastern states as far north as Washington undoubtedly refer to this species.

***Rhopalosoma bolivianum* sp. nov.**

*Female*.—Length 16 mm. Fulvo-ferruginous; the head paler and the apical portion of the abdomen darker apically, the last segment dark brown. Flagellum of antennae entirely black, except for the under side of the first segment at its base; space between the ocelli dark brown. Width of median ocellus one third less than its distance from the eye-margin, about equal to its distance from the posterior ocelli. Emargination of inner eye-margin moderately large and deep, acutely rounded at the bottom; its depth much less than the

thickness of the scape and about equal to the thickness of the first flagellar segment. Head in dorsal view almost twice as wide as long; seven eighths as high as wide in frontal view, measuring from the vertex to the lower margin of the clypeus. Surface of head above smooth and slightly shining; face below and clypeus weakly pilose, the hairs longer on the labrum, but quite sparse. Second flagellar segment one half longer than the first; third as long as the second. Thorax very sparsely clothed with very short pile; parapsidal furrows not extending in front of the anterior fourth of the mesonotum, narrow and very sharply defined. Petiole of abdomen not quite four times as long as high at its thickest portion where it is slightly narrower than high.

Type from Buena Vista, near Santa Cruz, Bolivia, J. Steinbach, 1928, in the Cornell University Collection.

***Rhopalosoma simile* sp. nov.**

*Female*.—Length 18–20 mm. Fulvo-ferruginous, the abdomen more or less stained with brown above beyond the second tergite; space between the ocelli black; antennae flagellum entirely black, width of median ocellus equal to its distance from the posterior ocelli. Emargination on inner margin of eye comparatively small, less than the thickness of the first segment of the antennal flagellum, nearly triangular in shape with the inner edge of the excavation very sharply rounded, almost pointed at the bottom. Head in dorsal view almost twice as wide as long; four-fifths as wide as high in frontal view, measuring from the vertex to the lower margin of the clypeus. Head smooth and rather strongly shining above, the face noticeably pilose; the labrum with dense, much longer hairs. Second flagellar segment slightly more than one and one half times as long as the first, subequal to the third. Thorax very weakly pilose. Parapsidal furrows deeper and wider than usual, especially anteriorly, not extending forward of the anterior third of the mesonotum. Petiole of abdomen clearly less than four times (375 : 100) as long as high at its thickest portion where it is as wide as high.

*Male*.—Length 13–14 mm. Considerably more slender and smaller than the female, but otherwise essentially similar, except for the secondary sexual characters. Darkened area between ocelli extended laterally almost to the eye-margin. In one male from Tuis, Costa Rica the eye-notch is deeper, but the head is asymmetrical and the specimen is apparently abnormal, although obviously not a gynandromorph.

Type female from Barro Colorado Island, Canal Zone, May 10–12, 1926 (C. T. Greene), in the U. S. National Museum. Paratypes: San Rafael Cumanacoa, Sucre, Venezuela, Nov. 8, 1929 (G. Netting), in the Carnegie Museum at Pittsburgh; Sixola River, Costa Rica (William Schaus), in the U. S. National Museum; Trinidad River, Panama, May 7, 1911 (August Busck), in the U. S. National Museum; Cayuga, Guatemala, May, 1915 (William Schaus), in the U. S. National Museum. Males from Trinidad River, Panama, May 8, 1911 (William Schaus),

and Tuis, Costa Rica, 2400 ft. (C. H. Lancaster), both in the U. S. National Museum. Five additional females were later loaned by the U. S. National Museum; four of these were collected by James Zetek at Barro Colorado, C. Z., and the other at Quirigua, Guatemala, by Wm. Schaus.

The type specimen bears a label indicating that it was taken at light, behavior which might be expected on account of the very large ocelli.

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A HUNDRED NEW SPECIES OF AMERICAN SPIDERS, by RALPH V. CHAMBERLIN and WILTON IVIE. Published as Vol. 32, No. 13. *Bull. Univ. of Utah*, pp. 117, 17 pls. which carry 230 figs. 1942. Paper bound. University of Utah, Salt Lake City, Utah.

Two excellencies appear in this publication. (1) Species descriptions have not been broadcast of many short papers in various journals. (2) The illustrations by Ivie are among the best that appear in entomological publications.

Chamberlin and Ivie among others are showing us what a rich spider fauna we have in North America. For carnivores it is remarkably large and complex. But then we do have the many insects which are not yet rationed to the spiders.

—C. H. K.

# THE LARVAE OF THE ARMY ANTS

GEORGE C. WHEELER,

University of North Dakota

Army ants are among the most notorious insects of the tropics. They have been written about by travelers and studied by entomologists for more than a century. But their larvae, by contrast, are seldom seen and have received comparatively scant attention even from myrmecologists.

Army ants belong to the Subfamily Dorylinae. The most conspicuous genera are *Dorylus* in the Old World tropics and *Eciton* in the Neotropical and southern Nearctic Realms. Less common is the Old World *Aenictus*. *Cheliomyrmex* is found only in the warmest parts of the Neotropical and is only locally abundant. The African *Aenictogiton* is known only from males. The genus *Leptanilloides* is known only from a few workers of the type species collected in Bolivia and its position in the Dorylinae is uncertain. *Leptanilla*, formerly regarded as a doryline, is now placed in a separate subfamily.

In this paper the larvae of thirteen species in four genera have been described. In addition I have included all the references to doryline larvae that I have been able to find in the literature.

## Subfamily *Dorylinae* Leach

Larvae elongate, slender, subcylindrical; with a slight progressive attenuation toward the anterior end; nearly straight but with the anterior end slightly curved ventrally; orthocephalic.<sup>1</sup> Twelve or thirteen distinct somites. Spiracles minute. Vestigial legs relatively large and conspicuous. Hairs short; sparse to moderately abundant; mostly simple (but branched or plumose in *Acamatus*). Head large, with short simple hairs. Antennae with two sensilla each. Mandibles poorly developed; of two types—elongate, slender, slightly curved and denticulate, or short, small, acuminate and feebly sclerotized. Maxillary palps wanting or represented by a more or less elevated group of sensilla. *Trophorhinium*<sup>2</sup> poorly developed or absent.

Wheeler (1922, p. 39) describes the larvae of the Dorylinae as "more or less cylindrical, with short hairs, without hooked setae; mandibles small, slender, falcate." Forel, 1928, Vol. I, p. 131 = 1921, Tome 1, p. 136: "More or less cylindrical, with short hairs and no hooked hairs" ("plus ou moins cylindriques, à poils courts, sans poils d'accrochage").

Emery (1904, p. 115) describes the doryline type as having a "forma sottile, quasi cilindrica."

Gallardo, 1920, p. 309: "Larvas más o menos cilíndricas, con pelos cortos, sin pelos para engancharse."

<sup>1</sup>*Orthocephalic*, having the head at the anterior end of the body, in contrast with *hypocephalic*, having the head apparently on the ventral surface near the anterior end.

<sup>2</sup>*Trophorhinium*, a term applied by Wheeler (1920, p. 257) to the aggregate of roughened surfaces of the mouth parts which might be used in triturating food.

"The less independent larvae of the Dorylinae receive from their ♂ balls of food prepared beforehand from the prey." Forel, 1928, Vol. I, p. 516=1922, Tome 3, p. 136: "Moins indépendantes, les larves des Dorylinae reçoivent de leurs ♂ des boulettes alimentaires toutes préparées faites avec des proies." Additional notes from Wheeler and Bailey on feeding may be found below under Eciton.

Wheeler found the larvae of the Dorylinae and those of the Cera-pachyinae to be extremely alike. "The mandibles are small, narrow, pointed and rather feebly chitinized, and I have failed to find a trophorhynchium in either group. Apparently the young are fed only on soft food." (1920, p. 50).

#### KEY TO THE GENERA OF DORYLINE LARVAE

1. Body relatively enormous; anterior end bent ventrally at an angle of 90°; terminal somite a very slender conical "tail"..... ♂ of **Dorylus**  
Not as above..... 2
2. Maxillary palp represented only by scattered sensilla..... **Dorylus** (**Anomma**)  
Maxillary palp, a conspicuous, compact group of sensilla, which is more or less elevated..... 3
3. Integument of body with neither spinules nor papillae..... **Aenictus**  
Integument with numerous minute spinules or papillae arranged in rows.... 4
4. Integument papillose..... **Eciton** s. str. and **E. (Labidus)**  
Integument spinulose..... 5
5. With only simple hairs on the body..... **Cheliomyrmex**  
With both simple and branched hairs on the body..... **Eciton (Acamatus)**

#### Tribe **Cheliomyrmicini** Wheeler

##### Genus **Cheliomyrmex** Mayr

Body hairs sparse, short, simple, flexuous. Integument spinulose. Head hairs numerous. Mandibles small, simple, acuminate, sharp-pointed, feebly sclerotized. Maxillary palp represented by a large convex, elliptical area bearing 11-15 sensilla.

**C. megalonyx** Wheeler.—Figs. 14-18. Moderately stout; orthocephalic; pro- and mesothorax slightly inclined ventrally forming an angle with the rest of the body, which is straight; thickest at the fourth abdominal somite, somewhat attenuated toward either end; posterior end bluntly pointed; anus subterminal; vestigial legs large rounded elevations. Minute vestigial gonopods on the seventh, eighth, and ninth abdominal somites. Twelve distinct body segments. Body rather sparsely clothed with simple flexuous hairs about 0.1 mm. long, arranged in bands around the middle of each segment; the anterior and posterior margins of each segment naked, except on the terminal segment where the hairs are uniformly distributed. Integument of body (but not of head) roughened with short transverse rows of exceedingly minute spinules, 3-6 in each row. Head large, cranium in anterior view subtrapezoidal, a trifle broader than long, broadest just above the level of the antennae; posterior angles broadly rounded. Head beset with numerous short (about 0.04 mm.) simple hairs. Antennae situated quite low on the cranium; each with two sensilla. Labrum small, transverse, twice as broad as long, appearing in profile as a short thick flap with the free edge rounded; the dorsal

surface bearing several short hairs, the ventral spinules in short arcuate rows. Mandibles small, simple and feebly sclerotized; basal half dilated; apical half acuminate. Maxillae large, subtriangular in anterior view, bearing a few small hairs; palp represented by an elevated elliptical area bearing 11-15 sensilla; galea a small papilla bearing two apical sensilla. Labium with the free end broadly rounded; palp represented by a minute circular elevation bearing four or five sensilla, and a single isolated sensillum nearby. Trophorhinium consisting only of the spinules on the ventral surface of the labrum. (Material studied: numerous specimens from British Guiana.)

In a recent paper (1938, p. 140) I have referred to the vestigial legs of this same species.



Text Figure 1. Male larva of *Dorylus (Anomma) wilverthi* Emery, photographed beside a centimeter scale.  $\times 1\frac{1}{2}$ .

### Tribe **Dorylini** Forel

#### Genus **Dorylus** Fabricius

Body hairs sparse, short, simple, flexuous. Integument without spinules or papillae. Head hairs few. Mandibles small, simple, acuminate, sharp-pointed, feebly sclerotized. Maxillae and labium inflated; typical palps and galeae lacking; numerous sensilla scattered over the surfaces.

Forel (1928, Vol. II, p. 298 = 1923, Tome 5, p. 116) states that the larvae of *Dorylus (Anomma)* "are much less nimble and more dependent upon the workers than those of the *Ponerinae*" ("bien moins ingambes et plus dépendantes des  $\text{\text{q}}$  que celles des *Ponerinae*").

**D. (Anomma) wilverthi** Emery.—Figs. 1-6. Slender, subcylindrical, orthocephalic, nearly straight but with the anterior end somewhat attenuated. Thirteen distinct postcephalic somites, the prothorax being the longest. Anus terminal. Vestigial legs relatively large convex elevations. Body beset with a very few simple hairs.

Head large; in anterior view somewhat longer than broad, with the cranium subhexagonal and bearing four groups of sensilla and a few simple hairs about 0.09 mm. long. Antennae large and convex, each with two sensilla. Front bulging and convex. Labrum transverse, short, and very thick; narrowed distally, with the anterior angles rounded; anterior surface bearing eight hairs similar to those on the cranium; numerous sensilla on the distal surface and two on the posterior surface. Mandible small and feebly sclerotized, with the base slightly expanded and the apex slender, straight, and acute. Maxillae inflated and subglobular, furnished with a few simple hairs; palp represented by a loose cluster of 14–21 sensilla, one of which is mounted on a small projection; galea a short, rather stout papilla, apparently without sensilla. Labium with the prementum swollen, moderately large, and feebly impressed at the middle of the distal surface; postmentum inflated and sagging; palp represented by a diffuse cluster of sensilla, some of which bear a spinule; opening of sericteries a long transverse arcuate groove. Trophorhynchium wanting. (Material studied: Four slightly damaged specimens from the Belgian Congo.)

A number of years ago I had the opportunity of photographing (Text fig. 1) a male larva of this species from the Belgian Congo, but was unable to obtain the specimen for further study. Apparently it is indistinguishable from the male of *D. molesta* described below.

There is a reference in my paper on vestigial legs (1938, p. 140) to the above species.

*D. (Anomma) nigricans* Illiger.—Forel (1912, Pl. I, fig. 6) has figured a semipupa.

*D. (Anomma) nigricans* var. *molesta* (Gerstcker). *Male*.—Fig. 7. Size enormous (relative to worker); length of mid-dorsal line 47 mm.; maximum diameter (at 5th abdominal somite) 8.8 mm. Body moderately stout, subcircular in cross-section, tapering gradually toward the ends, which are both acute. Anterior portion, *i. e.*, first six somites, bent ventrally at an angle of 90 degrees. Thirteen distinct somites. Terminal somite having the shape of a slender cone—much more slender than the penultimate somite, into which it is partially retractile. Penultimate somite having a shape somewhat like the

#### EXPLANATION OF PLATE I

##### *Dorylus*, *Aenictus*, and *Cheliomyrmex*

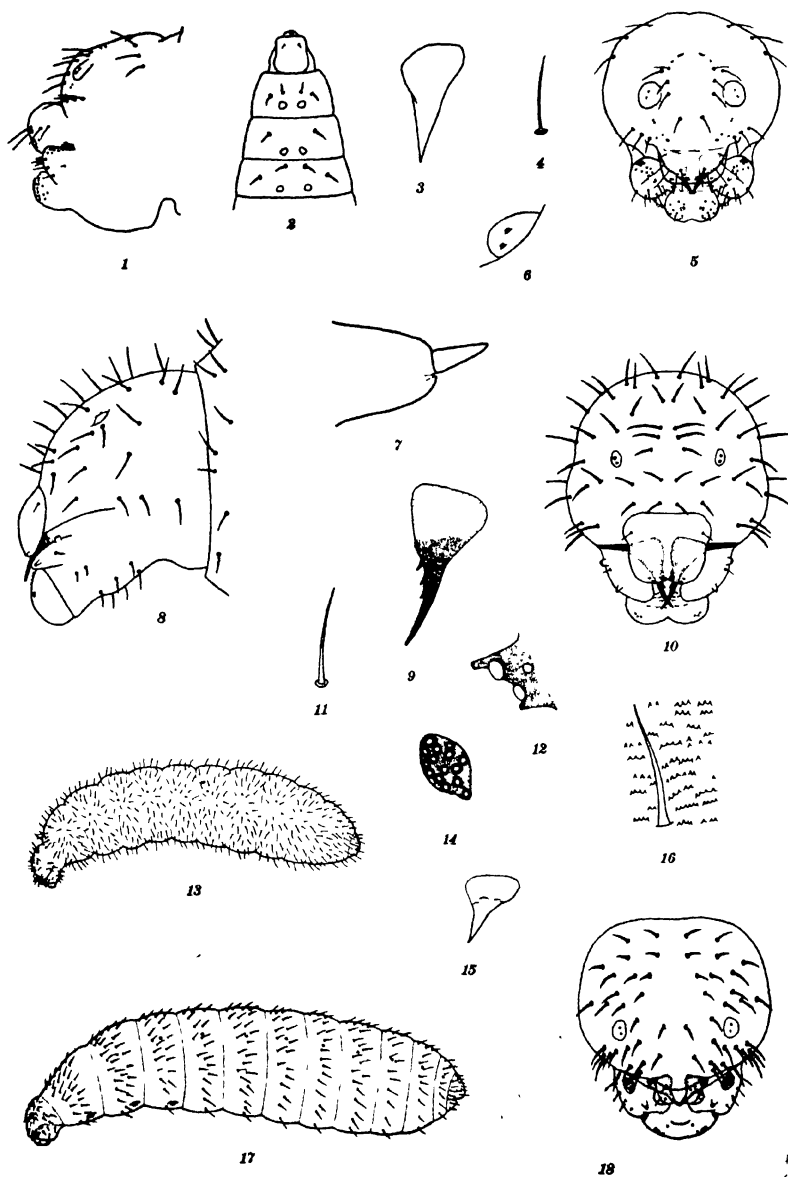
*Dorylus (Anomma) wilverthi* Emery, Figs. 1–6. 1, head in side view,  $\times 53$ ; 2, head and thorax in ventral view,  $\times 17$ ; 3, mandible in anterior view,  $\times 133$ ; 4, body hair,  $\times 185$ ; 5, head in anterior view,  $\times 53$ ; 6, antenna in side view,  $\times 175$ .

*Dorylus (Anomma) nigricans* var. *molesta* (Gerstcker), ♂. Fig. 7, last two somites in side view,  $\times 4$ .

*Aenictus (Typhlatta) leviceps* (F. Smith), Figs 8–10. 8, head in side view,  $\times 91$ ; 9, mandible in anterior view,  $\times 197$ ; 10, head in anterior view,  $\times 91$ .

*Aenictus (A.) aratus nesiotis* var. *fraterculus* Wheeler, Figs. 11–13. 11, body hair,  $\times 253$ ; 12, maxillary palp,  $\times 333$ ; 13, larva in side view,  $\times 17$ .

*Cheliomyrmex megalonyx* Wheeler, Figs. 14–18. 14, maxillary palp,  $\times 211$ ; 15, mandible in anterior view,  $\times 133$ ; 16, body hair and integumentary spinules,  $\times 181$ ; 17, larva in side view,  $\times 14$ ; 18, head in anterior view,  $\times 61$ .





frustrum of a cone; anus on the apical end beneath the base of the terminal somite. Spiracles exceedingly minute in porportion to body size. No hairs on body. Head relatively very small, the maximum breadth being only 0.6 mm. The head is, in fact, so small and delicate in proportion to the vast bulk of the body that it is easily broken off from preserved larvae, especially when shipped in vials with other specimens. Most of the larvae available to me have therefore been decapitated. On the basis of inadequate material, the head seems to be quite similar to that of the worker larva of *D. wilverthi*. (Material studied: several larvae collected in Kenya by G. van Someren and made available to me through the courtesy of Dr. N. A. Weber.)

**D. (D.) affinis** Shuckard.—Emery (1901) has figured (Pl. II) a ♂ semipupa in side view (fig. 1), head of same in side view (fig. 2), ventro-lateral view of head (fig. 3), and mouth parts in side view (fig. 4). His description (p. 429) follows:

"Queste larve sono tutte bianchissime, subcilindriche, debolmente assottigliate in avanti, coi segmenti poco marcati. Sono fornite di peli piuttosto lunghi, ma semplici e poco numerosi, disposti in zone segmentali che si riducono a semplici serie trasversali sui segmenti posteriori del corpo. Il capo é piccolo, ritondato. Labbro superiore e mascelle sono ritondati, queste sono fornite di alcune papille non colorate né notevolmente sporgenti, ultimo rudimento forse delle due punte che offrono nelle larve delle Ponerine. Il labbro inferiore costituisce anch'esso una sporgenza rotonda, un poco incavata nel mezzo superiormente, ed é fornito di peli e di alcune piccole papille; nessun vestigio di filiera. Le mandibole sono molto piccole, acuminate, brune. Al disopra della bocca, il capo presenta un paio di piccole sporgenze lenticolari che credo debbansi considerare come rudimenti di antenne. Se si esamine una larva in cui le antenne dell'immagine siano già formate, ma il capo non si sia ancora staccato dalla cuticola larvale, l'estremità delle antenne corrisponde ai rudimenti anzidetti."

### Tribe *Ecitonini* Forel

Body hairs moderately abundant; short, simple or branched. Head hairs simple. Mandibles elongate, slender, slightly curved, with the medial border denticulate.

#### EXPLANATION OF PLATE II

##### *Eciton*

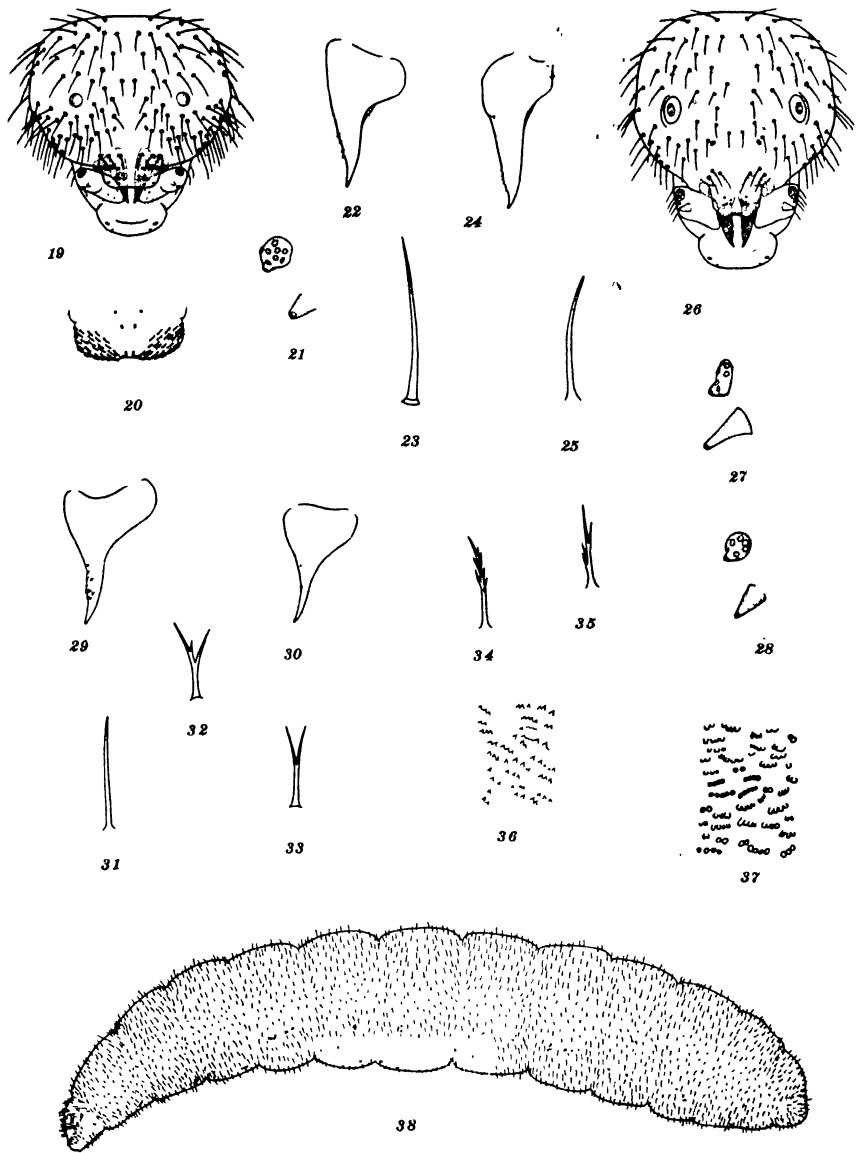
*Eciton* (*E.*) *hamatum* (Fabricius), Figs. 19–23 and 38. 19, head in anterior view, × 49; 20, labrum in posterior view, × 87; 21, maxillary palp and galea, × 167; 22, mandible in anterior view, × 108; 23, body hair, × 185; 38, larva in side view, × 12.

*Eciton* (*Labidus*) *coecum* (Latreille), Figs. 24–28. 24, mandible in anterior view, × 153; 25, body hair, × 185; 26, head in anterior view, × 73; 27, maxillary palp and galea in profile, × 187; 28, maxillary palp and galea in face view, × 187.

*Eciton* (*Acamatus*) *schmitti* Emery, Figs. 29–33. 29, mandible of ♂ in anterior view, × 83; 30, mandible of ♀ in anterior view, × 167; 31–33, body hairs, × 185.

*Eciton* (*Acamatus*) *pilosum* F. Smith, Figs. 34–36. 34–35, body hairs, × 185; 36, integumentary spinules, × 185.

*Eciton* (*E.*) *burchelli* (Westwood), Fig. 37, integumentary papillae, × 181.



Genus *Aenictus* Shuckard

Body hairs simple. Integument without spinules or papillae. Hairs of head few. Labrum large and conspicuous. Maxillary palp represented by three subconical sensilla fused into an irregular projection.

**A. (*Typhlatta*) *leveps*** (F. Smith).—Figs. 8–10. Slender, subcylindrical; diameter greatest at the fifth abdominal somite; orthocephalic, nearly straight but slightly curved ventrally toward the anterior end; posterior end bluntly rounded. Twelve distinct postcephalic somites. Anus terminal. Vestigial legs small and papilliform. Body and head furnished with a moderately dense covering of simple, slightly curved hairs about 0.05 mm. long. Cranium subtrapezoidal in anterior view with the posterior border broadly rounded and the genae bulging. Antennae small, each with two sensilla. Labrum convex; somewhat broader than long, being broadest above the mandibles; distal border emarginate at the middle; lateral borders feebly emarginate over the mandibular bases; anterior angles broadly rounded; eight spinulose sensilla along the distal border. Mandibles rather heavily sclerotized; base dilated, distal portion very long and slender and curved posteriorly; apex acute; three small teeth near the middle of the medial border. Maxillae round-pointed; palp short and thick with three distal sensilla; galea somewhat more slender, subconical, with one apical sensillum. Labium swollen, protruding, bilobed; palps represented by two clusters of three sensilla each; anterior surface roughened with short rows of spinules; opening of sericteries not evident. Trophorhinium poorly developed, including only the spinulose surface of the labium. (Material studied: numerous specimens from the Philippine Islands.)

**A. (*T.*) *martini*** Forel.—Similar to *A. leveps*. (Material studied: numerous specimens from the Philippine Islands.)

**A. (*A.*) *aratus nesiotis* var. *fraterculus*** Wheeler.—Figs. 11–13. Similar to *A. leveps*, but the maxillary palp and galea are larger and the former bears six sensilla. (Material studied: numerous specimens from the Philippine Islands.)

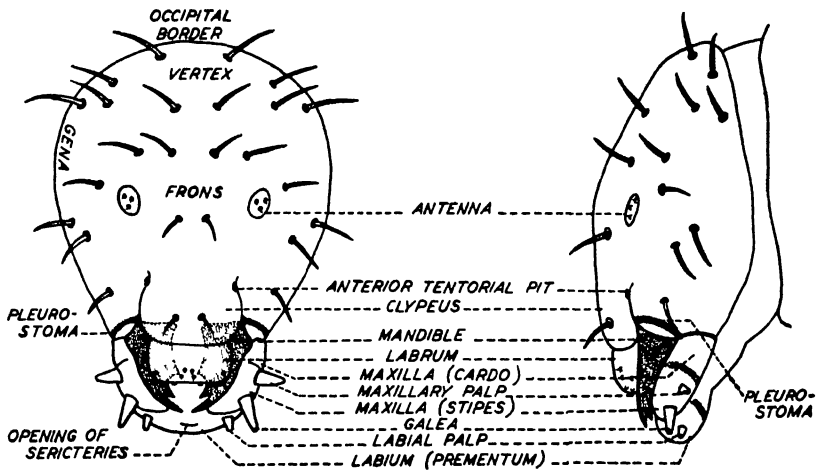
Genus *Eciton* Latreille

Body with simple hairs (*Eciton s. str.* and *Labidus*) or with both simple and branched hairs (*Acamatus*). Integument papillose (*Eciton s. str.* and *Labidus*) or spinulose (*Acamatus*). Labrum small and inconspicuous. Maxillary palp represented by a discoidal area bearing 5–9 sensilla.

Escherich (1917, p. 95) characterizes *Eciton* larvae as "*annähernd zylindrisch*."

Forel (1928, Vol. II, p. 298=1923, Tome 5, p. 116) states that the larvae of *Eciton* "are less nimble and more dependent upon the worker than those of the *Ponerinae*" ("*bien moins ingambes et plus dépendantes des ♂ que celles des Ponerinae*"). Wheeler (1910, p. 72) describes the larvae of this genus as cylindrical and states (p. 263) that those of Texan species are slender.

**E. (E.) hamatum** (Fabricius).—Figs. 19–23 and 38. Slender, sub-cylindrical, orthocephalic; with the anterior end slightly curved ventrally and the rest of the body nearly straight; thickest at the sixth abdominal somite, attenuated toward either end; posterior end bluntly pointed. Vestigial legs relatively large (diameter 0.05 mm.) rounded elevations. Anus ventral. Thirteen distinct postcephalic somites, the terminal small. Body provided with a moderately dense covering of short (0.025–0.12 mm.) simple hairs, which are uniformly distributed. Integument of body beset with short transverse rows of minute papillae, 3 or 4 in each row. Head small, cranium transversely subelliptical in anterior view; rather thickly beset with simple hairs about 0.1 mm. long. Antennae in the form of a minute paraboloid bearing two minute sensilla and mounted eccentrically on a low



Text Figure 2. Synthetic head of an ant larva to illustrate terminology.

elevation. Labrum small, thick, twice as broad as long, with the distal border nearly straight; numerous sensilla on the dorsal surface, a few on the ventral surface and distal border; ventral surface roughened with short arcuate rows of spinules. Mandibles long and narrow with the base dilated, feebly sclerotized and somewhat variable in shape; the apical portion slender and slightly curved medially but not posteriorly; medial borders sparsely denticulate. Maxillae large; the stipes conoidal and furnished with a few spinules; palp a discoidal area bearing one ungulate and 4–8 discoidal sensilla; galea a truncate cone with two apical sensilla. Labium prominent; the prementum subhemispherical; palp a group of four sensilla, three of which form a compact cluster, the fourth isolated; opening of sericteries a long transverse, arcuate slit. Trophorhinium consisting of the spinulose ventral surface of the labrum and the spinules on the maxillae. (Material studied: numerous specimens from the Panama Canal Zone.)

Schnierla has discussed the influence of larvae upon the behavior of the colony:

"The *Eciton* colony makes its nest by gathering into a cluster, and the site of this 'bivouac' changes from time to time. In *E. hamatum* and *E. burchelli* one may ascertain two conditions of general activity, which alternate according to the conditions of the brood. [Schnierla's footnote, p. 321: "W. Müller (Kosmos, 1886), from his study of an *Eciton burchelli* colony, was first to suggest the possibility of a relationship between the food-consuming ability of the *Eciton* colony, as affected by the presence of active larvae, and the general activity of the group."] The colony remains bivouacked in a given place, in the 'statory condition,' first when the eggs are present and during the period that precedes the development of the eggs into food-consuming larvae, and secondly during the period of about three weeks when the young are enclosed in cocoons. In contrast, the colony moves to a new bivouacked site each evening (is in the 'nomad condition') during the time the larvae are naked and consuming food, and again, after the brood has been hatched. Colonies in the statory condition are less active, and raid much less vigorously than when in the nomad condition." (1934, p. 319.)

"The nomadic phase is maintained as a result of the activity of developing larvae. . . . The movements of these larvae, particularly the active twisting movements of their anterior ends, shortly become an important source of stimulation to adult workers. For this it is important that the larvae as they grow larger and become more active are not massed together in the very center of the bivouac as before, but are held by individual workers or are piled up in small numbers in the spaces between ant-strands throughout the interior of the bivouac." (1938, p. 68.)

"To summarize, the foregoing theory is built upon the fact that a brood of larvae which contains many thousands of individuals all at the same stage in development, incidentally stimulates the adults through its activity and thereby greatly increases the general level of colony excitement. This accounts for the marked vigor of each day's raiding, and for the developments of raiding systems by great numbers of workers to an extent which makes a colony migration inevitable at the end of the day. When the maintaining cause ceases to function, colony excitement is markedly reduced and the value of raiding activity falls considerably below the threshold necessary for a general migration. Consequently the colony then enters a very different activity phase in which true migration does not occur." (1938, p. 75.)

In a recent paper (1938) I have described the vestigial legs (p. 140 and figs. 1, 2, and 3) and the vestigial gonopods (p. 141 and fig. 1) of this species. The absence of wing rudiments was also noted (p. 141).

The larval stage of *E. hamatum* lasts 20 days (Schnierla, 1938, pp. 58-61).

**E. (E.) burchelli** (Westwood). Fig. 37. The mature larva of this species is very similar to that of *E. hamatum*. The distal and lateral borders of the labrum are slightly concave; the maxillary palp has 6-9 sensilla; the galea is a trifle longer and more slender. (Material studied: numerous specimens from Trinidad collected by Dr. N. A. Weber.)

The young larva (i.e., 4-5 mm.) of *E. burchelli* resembles the mature

larva except as follows: the intersegmental furrows are impressed on the sides; the leg vestiges are small and feebly developed; the genae bulge at the level of the antennae; no spinules on the ventral surface of the labrum; the mandibles are a trifle stouter.

Emery (1899, p. 6) described the larva of *E. burchelli*: "Sono entrambe larve subcilindriche, coi segmenti tutti distinti; sono prive di tubercoli o altre appendici e fornite di peli numerosi, brevi e semplici, non esistono peli forcuti, ritorti o uncinati." On Pl. II he figured a larva in profile (fig. 6a), a head in profile enlarged (fig. 6b), mouth parts from in front (fig. 6c), and a mandible and maxilla in profile (fig. 6d).

In an article in the *Atlantic Monthly* (1919, pp. 454-464) Beebe has described (p. 463) cocoon-spinning by the larvae of *E. burchelli* (quoted also by Wheeler, 1921, p. 300). I am quoting it here by permission of the *Atlantic Monthly*:

"On the flat board were several thousand ants and a dozen or more groups of full-grown larvae. Workers of all sizes were searching everywhere for some covering for the tender immature creatures. They had chewed up all available loose splinters of wood, and near the rotten, termite-eaten ends, the sound of dozens of jaws gnawing all at once was plainly audible. This unaccustomed, unmilitary labor produced a quantity of fine sawdust which was sprinkled over the larvae. I had made a partition of a bit of a British officer's tent which I had used in India and China, made of several layers of colored canvas and cloth. The ants found a loose end of this, teased it out, and unraveled it, so that all the larvae near by were blanketed with a gray parti-colored covering of fuzz.

"All this strange work was hurried and carried on under great excitement. The scores of big soldiers on guard appeared rather ill at ease, as if they had wandered by mistake into the wrong department. They sauntered about, bumped into larvae, turned and fled. A constant stream of workers from the nest brought hundreds more larvae, and no sooner had they been planted and debris of sorts sifted over them, than they began spinning. A few had already swathed themselves in cocoons—exceedingly thin coverings of pinkish silk. As this took place out of the nest, in the jungle, they must be covered with wood and leaves. The vital necessity of this was not apparent, for none of this debris was incorporated into the silk of the cocoons, which were clean and homogeneous. Yet the hundreds of ants gnawed and tore and labored to gather this little dust, as if their very lives depended upon it. . . . When first brought from the nest, the larvae lay quite straight and still, but almost at once they bent far over in the spinning position. Then some officious worker would come along, and the unfortunate larva would be snatched up, carried off, and jammed down in some neighboring empty space, like a bolt of cloth rearranged upon a shelf. Then another ant would approach, antenna the larva, disapprove, and again shift its position. It was a real survival of the lucky, as to who should avoid being exhausted by kindness and over-solicitude. . . . There was no order of packing. The larvae were fitted together anyway, and meagerly covered with dust of wood and shreds of cloth. One big tissue of wood nearly an inch square was too great a temptation to be left alone, and during the course of my observation it covered

in turn almost every group of larvae in sight, ending by being accidentally shunted over the edge and killing a worker near the kitchen middens. There was only a single layer of larvae; in no case were they piled up, and when the platform became crowded, a new column was formed and hundreds taken outside. To the casual eye there was no difference between these legionnaires and a column bringing in booty of insects, eggs and pupae; yet here all was solicitude, never a bite too severe, or a blunder of undue force."

According to Wheeler and Bailey (1920, pp. 254-255) the stomach of the larval *E. burchelli* "is unlike that of any other known ant-larvae in being very long and slender and in having unusually thick, muscular walls. The larva is fed, apparently at considerable intervals, with rather large pellets consisting of the rolled up soft-parts of insects. These pellets are so compact that they retain their form in the narrow lumen of the stomach, where they lie in an irregular longitudinal series. Occasionally minute fragments of chitin or a few fungous spores are present, but owing to the feeble development of the larval mouth-parts so characteristic of the Dorylinae, it is evident that the worker must prepare these pellets by carefully trimming away the hard, chitinous portions of their insect prey and rolling up the denser, muscular portions of the flesh. The worker probably consumes much of the exuding juices while engaged in this operation and before stuffing the pellets into the gullets of the larvae."

The passage from Müller (1886, p. 87) referred to above in Schnierla's footnote under *E. hamatum* is as follows: "Der Punkt, wo der Wechsel eintritt, fällt ungefähr zusammen mit dem, wo sich die letzten Larven einspinnen, und dieses Zusammentreffen ist jedenfalls kein zufälliges. Larven brauchen ja im allgemein, besonders kurze Zeit vor der Verpuppung, bedeutend mehr Nahrung als die fertigen Insekten, und so scheint nichts natürlicher, als dass das Nahrungsbedürfnis der Gesellschaft ein geringeres wird und die Tiere entsprechend weniger auf Beute ausgehen, nachdem alle Larven eingesponnen."

Müller's paper bears the title "Beobachtungen an Wanderameisen (*Eciton hamatum* Fabr.)." Wheeler, however, has shown (1921, p. 293) that the species was in reality *E. burchelli*.

Müller described the larvae as "schlank" (p. 82). He observed (p. 89) that spinning and pupation of all larvae takes place within a comparatively short time; from this he concluded that all the individuals were of approximately the same age and that all eggs had been laid within the space of a few days. He also reported (p. 90) that the largest larvae spun first and developed into soldiers. Then followed the largest workers and after them the remaining workers; the younger the larvae were (or the later they pupated) the smaller were the emerging workers.

The specimens regarded by Müller (1886, p. 91 and fig. 2) and by Forel (1891, p. 163) as heteromorphic *Eciton* larvae are actually some ponerine larva (*Pachycondyla*) which had been taken in a raid. (Emery, 1900, p. 513, and Wheeler and Long, 1901, pp. 168-172.)

Schnierla's discussion (1934, p. 319) of the influence of the larvae of *E. burchelli* upon the behavior of the colony may be found above under *E. hamatum*.

**E. (E.) quadriglume dulcius** var. **jujuyensis** Forel.—Gallardo (1920, p. 324) says of this form: "Se puede notar la esbeltez de las larvas que les permite una gran movilidad. . . ." Fig. 8 (on p. 322) is an excellent photograph of these larvae.

**E. (E.) vagans** (Olivier). These larvae are very similar to *E. hamatum*. (Material studied: numerous specimens from Trinidad collected by Dr. N. A. Weber.) In a recent paper (1938) I have figured (fig. 5) a section through an imaginal bud and vestigial leg.

**E. (Acamatus) schmitti** Emery—Figs. 29–33. Apparently similar to *E. hamatum*, except in the following characters. The body is densely and uniformly covered with hairs of two types: the majority are simple, straight or slightly curved, and 0.06–0.09 mm. long; a few are bifid or trifid and about 0.05 mm. long. The integument is furnished with short transverse rows of minute spinules. The labrum has 12 sensilla on the anterior surface and lacks spinules on the posterior surface. The apical portion of the mandibles is more slender; the point is more acute; and the denticles are minute and very few in number. The maxillae are without spinules; the palp bears 7 sensilla. Trophorhynchium wanting. (Material studied: 8 badly damaged specimens from Colorado).

I have studied a number of male larvae of this species extracted from cocoons 13 mm. long, which were collected in Texas by my brother, Dr. P. A. Wheeler. Since the larvae attain a length of 14–15 mm., the anterior end is sharply recurved to fit the shorter cocoon. In general, however, the shape is typically ecitonine. The wing rudiments appear as short transverse lines (grooves?); vestigial gonopods are wanting on the seventh and eighth abdominal somites and there is only a faint trace on the ninth. There are 13 distinct body somites. The body has a moderately dense covering of hairs which are uniformly distributed in transverse bands separated by naked zones along the shallow intersegmental furrows. These hairs are relatively minute (0.10–0.16 mm.), with the longest at the posterior end where they are flexuous with fine attenuate tips. So many hairs are broken off that the apparent absence of branched hairs is inconclusive; all remaining hairs are simple. The integumental spinules are like those of the worker. The heads of all my specimens are distorted by preservation but they seem to resemble the head of *E. hamatum*, except for genal bulges. The mouth parts resemble those of *E. hamatum* except as follows: the apical portion of the mandibles is more slender, with the denticles larger, more obtuse, and more numerous; the maxillae seems to lack spinules. The mandibles are relatively somewhat smaller than those of the worker.

In a recent paper (1938) I have described the wing rudiments (p. 141) and vestigial gonopods (p. 142) and figured the thorax of the above male in ventral view (fig. 4).

An examination of one damaged larva and one extra head of *E. (A.) sumichrasti* Norton (from Mexico) reveals its close similarity to the larva of *E. (A.) schmitti*.

**E. (A.) pilosum** F. Smith (figs. 34–36). The larva of this species is likewise similar to *E. (A.) schmitti*, but the hairs are all stiff and plumose and the maxillary palp has only five sensilla. This conclusion is based on eight unsatisfactory specimens from Paraguay.



**Eciton (Labidus) coecum** (Latreille).—Figs. 24–28. Resembles *E. hamatum*, except in the following characters. The covering of hairs is much less dense. On the thorax the hairs are 0.09–0.11 mm. long and resemble those of *E. hamatum* in form; on the abdomen they are shorter, (0.054–0.072 mm.), stouter, and stiffer, and taper abruptly to a short, sharp point. Hairs of head shorter (0.036–0.054 mm.). The breadth of the labrum is less than twice the length. No spinules were found on the maxillae. The maxillary palp bears six sensilla with the unguulate sensilla more elongate than in *E. hamatum*; the galea is longer and more slender. Opening of sericteries inconspicuous. (Material studied: numerous specimens from British Guiana collected by Dr. N. A. Weber.)

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## THE GENERAL COUNCIL ON ZOOLOGICAL NOMENCLATURE

The undersigned zoologists, resident in the United States of America, at the invitation of the Committee on Nomenclature of the American Society of Mammalogists and with the co-operation of the "American Commission on Scientific Nomenclature" of the Entomological Society of America, do hereby associate themselves together as a society and certify as follows:

First: The name of the society shall be the General Council on Zoological Nomenclature.

Second: The objects of the Society shall be:

- (A) To act in an advisory capacity in all matters concerning zoological nomenclature during the World War and for such time thereafter as it may consider desirable.
- (B) To administer, amend, interpret, and maintain a code of nomenclature for the use of zoologists.
- (C) To co-operate with societies maintaining committees on nomenclature, at least those represented in its own membership.
- (D) To retain within itself important powers of decision and legislation and of substitutions and additions to its membership, but always subject to full hearings and the advice and counsel of one or more of the committees above mentioned.
- (E) To co-operate with zoologists practised in nomenclature who are residents of foreign countries when the war is ended or as soon thereafter as may be practicable.

G. F. FERRIS  
WILFRED H. OSGOOD  
JAMES A. G. REHN  
GEORGE G. SIMPSON  
JOHN T. ZIMMER

REMINGTON KELLOGG  
H. A. PILSBRY  
KARL P. SCHMIDT  
A. WETMORE

Merely on the face of it, the above may seem to be a self-constituted body of dubious possibilities and audacious construction. That this is not the case may be evident when its history and purposes are explained. It is the outgrowth of numerous informal discussions among a large number of zoologists during the past few years and of formal action taken by at least two national societies.

Even in years just prior to the war, the International Commission on Zoological Nomenclature was relatively inactive and after hostilities began in Europe in 1939 it became practically nonfunctional. This created a situation in which all co-operative action was endangered and nearly a century's hard earned progress in nomenclature was threatened. Individuals and organizations began to discuss special codes for their separate groups only, and in some cases took definite action. Recently a German (Poche) has promulgated a code of his own and in general at the moment every zoologist having a nomenclatural problem finds himself without appeal to any constituted authority. It was precisely to avoid this condition that codes and commissions were devised.

Discussion among zoologists unanimously recognized the emergency, but it was difficult to arrive at a basis for action which did not involve very great delay and longdrawn controversy. There were those who felt that the international idea could not be abandoned and others who advocated complete divorce from the Old World. The latter pointed

to the success of the International Commission as being mainly due to the American C. W. Stiles whose final conclusion (see *Science*, 73, pp. 349-354, 1931) was that it was not further workable. Among those holding this opinion were several Europeans.

As announced in *Science* (June 12, 1942) the Entomological Society of America, pursuant to action taken at its meeting in December, 1941, formed an "American Commission on Scientific Nomenclature in Entomology" apparently with the object of proceeding independently. Somewhat later at its annual meeting in April, 1942, the American Society of Mammalogists instructed its standing committee on nomenclature "to act pro-tem in the present world crisis for the Committee (sic) on Nomenclature of the International Commission." The Mammalogists' Committee felt that any committee restricted to a particular branch of zoology would be ineffective. Therefore, with the approval of the Society's President and principal directors, this committee entered into correspondence with the entomologists proposing that the two committees, without further authorization, jointly sponsor the selection of a small group of representative nomenclaturists to "take over," at least for the time being. Full co-operation between the two committees proved impractical without great loss of time, so the Mammalogists' Committee, after receiving encouragement from the majority of the entomologists, selected and organized the group as indicated above. The membership of the Mammalogists' Committee which carried this out was as follows: A. Cabrera, E. R. Hall, G. S. Miller, Jr., W. H. Osgood, T. S. Palmer, G. G. Simpson, and G. H. Tate.

The "Council" thus formed is frankly experimental and the method of its genesis is unusual, but those responsible for it have felt that any other method, especially in these times when large general meetings are interdicted, would defeat itself in prolonged discussion and fatal delay. Under restrictions which the Council has placed upon itself it is hoped that it may be a wholly representative and co-operative body. A brief set of by-laws has been adopted in which important provisions are to the effect (1) that the active membership shall not exceed fifteen, (2) that additions and replacements shall be made only from candidates nominated by large associations of zoologists, and (3) that no important action can be taken without first obtaining the opinion of at least two nomenclatural committees of national societies and several individuals not members of the Council. A judicial function is thus implied preceding any legislation.

It does not propose to supersede any existing special nomenclatural committees, but on the contrary it is designed to stimulate them to greater interest and more action. Its postwar status is problematical, but at least as a temporary measure and an effort in a direction urgently needing attention, it is hoped it may find support. At any early date it is proposed to increase the membership from nine to eleven in order to cover important branches of zoology which are not now well represented.

The by-laws giving details of proposed action are now available for distribution to any interested zoologists who may apply for them

WILFRED H. OSGOOD, *Secretary*,  
Field Museum of Natural History, Chicago.

## THE FOUNDATION FOR THE STUDY OF CYCLES

The Foundation for the Study of Cycles—a non-profit organization created to foster, promote, and conduct scientific research in respect to rhythmic and periodic fluctuations in any branch of science—announces the offering of a medal to the person who, during 1943, publishes the book or paper in this field that in the opinion of the judges is the most outstanding.

The judges are Dr. C. G. Abbot, Solar Physicist and Secretary of the Smithsonian Institution; Dr. Harold E. Anthony, Curator of Mammals and Dean of Scientific Staff, American Museum of Natural History; Professor W. C. Mitchell, Professor of Economics, Columbia University, and Director of the National Bureau of Economic Research; Professor V. C. Wynne-Edwards, Professor of Zoology, McGill University; and Professor Ellsworth Huntington, Professor of Geography and Climatology, Yale University (Chairman).

It may be in point to recite some of the reasons for assigning high importance to research in cyclic phenomena.

First, in dealing with rhythm and periodicity the scientist is at the very heart of predictability. The power to predict accurately is the acid test of the degree of precision reached in any science. Medical science, for example, would become vastly more effective if we understood the degree to which various diseases are rhythmic in occurrence. Similarly, accurate long range weather predictions, which would be of inestimable value in agriculture and aviation, depend on a knowledge of the nature and causes of the more or less rhythmic variations observed now and in the past.

Second, the techniques for dealing with rhythms and periodicities are much the same in one branch of science as in another, but unless the subject is considered a field by itself, advance in methods in one discipline is often unknown in another until after the lapse of many years.

Third, the subject of rhythmic and periodic fluctuations is important because identical rhythms in unrelated phenomena and unrelated fields of science suggest possible interrelationships that might otherwise escape notice. For instance, long before the cause of tides was understood, the fact that the period of the tides is exactly half the period of the moon suggested that the moon must have something to do with the ebb and flow of the waters.

These are some of the reasons why a concerted study of cycles as a whole is important. There are of course other reasons in respect to individual branches of science.

We must all be careful not to confuse contributions to our knowledge of *interrelationships* with contributions to the knowledge of rhythms and periodicities *per se*. There may be an excellent correlation between two phenomena, and yet no rhythms may be involved in either. The direct concern of the Foundation for the Study of Cycles is only with rhythms and periodicities as such. We must also keep in mind that *denial* of the existence of a rhythm may be as important as affirmation.

In addition to awarding a medal, the Foundation will make awards to outstanding work in each branch of science. In these awards the judges will be assisted by the recommendation of an advisor appointed by a scientific society in the branch involved.

The following societies have appointed advisors:

<b>Agriculture—</b>	<b>Mammalogy—</b>
Am. Soc. of Agronomy	Am. Soc. of Mam.
<b>Astronomy—</b>	<b>Medicine—</b>
Am. Assn. of Variable Star Observers	Am. Medical Assn.
<b>Bacteriology—</b>	<b>Mycology—</b>
Soc. of Am. Bacteriologists	Mycological Soc.
<b>Botany—</b>	<b>Paleontology—</b>
Botanical Soc. of Am.	Paleontological Soc.
Sec. on Botanical Sciences, A.A.A.S.	<b>Seismology—</b>
<b>Ecology—</b>	Seismological Soc.
Ecological Society	<b>Sociology—</b>
<b>Entomology—</b>	Am. Sociological Soc.
Entomological Soc. of Amer.	<b>Statistics—</b>
<b>Forestry—</b>	Am. Statistical Assn.
Soc. of Am. Foresters	Insti. of Mathematical Statistics
<b>Geography—</b>	<b>Zoology—</b>
Assn. of Am. Geographers	Am. Soc. of Zoologists
<b>Geophysics—</b>	Sec. on Zoological Sciences, A.A.A.S.
Am. Geophysical Union	

Other societies have indicated that advisors will soon be appointed.

ELLSWORTH HUNTINGTON, *Chairman.*

THE FLEAS OF NORTH AMERICA, by H. E. EWING and IRVING FOX. U. S. Dept. Agr. Misc. Publ. No. 500. 141 pp., 57 figs. Index. 1943. Sold by Superintendent of Documents, Washington, D. C. Price 20 cents.

This is a very timely publication with the development of Sanitary Corps and the present general emphasis on the greatly broadened battle against disease carrying insects. Only two previous large publications on American fleas have ever been published, Parker, 1904, on all American fleas and I. Fox, 1940, on fleas of the western United States. The present volume considers all work down to Oct. 1, 1940. Emphasis has been on the study of material on which previous publications were based. Considerable care has been taken in the definition of groups and of species. Rules as to what should be considered generic or subgeneric characters and what should be used as specific characters were laid down in the problem of the valid status of each form. We hope the authors were able to stick to their rules.

The volume lists 61 genera, 14 subgenera, 209 species, and 63 subspecies and varieties. The area covered is that of North America and the West Indies.

—C. H. K.

# MEMBERS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA ENROLLED IN THE ARMED AND RELATED SERVICE OF THE UNITED STATES<sup>1</sup>

ALLEN, THEO.

ARCHER, SGT. A. F., Sanitary Technicians' School, Camp Grant, Ill.

BABERS, MAJ. FRANK H., 0228835, Hdq. 39th C. A. Brig. A. A., Seattle, Wash.

BAKER, LT. COL. A. W., Royal Canadian Naval Volunteer Reserve.

BARNES, RALPH C., U. S. P. H. S., P. O. Box 210, Jacksonville, Fla.

BARNETT, SGT. HERBERT C., Division of Parasitology and Tropical Medicine, Army

Medical School, Army Medical Center, Washington, D. C.

BARRETT, PVT. PAUL H., Med. Det., Percy Jones General Hospital, Battle Creek, Mich.

BARRETT, W. L., JR.

BELKIN, 1ST LT. JOHN N., Sn. C., M. D. R. P., M. R. T. C., Camp Joseph T. Robinson, Ark.

BENTON, CURTIS, Med. Corps, Purdue University, Lafayette, Ind.

BERNER, CAPT. LEWIS, 0461681, Hq. Africa Middle East Wing, A. T. C., A. P. O. 625, c/o Postmaster, Miami, Fla.

BERTAGNOLLI, 2ND LT. ALFRED A., 877 Chemical Company, Barksdale Field, La.

BICKLEY, WM. E., U. S. P. H. S. (R), 300 Essex Building, Norfolk, Va.

BILLINGS, LT. S. C., Norfolk Army Base, H. R. P. E., Norfolk, Va.

BLANTON, LT. F. S., Sn. C., Fort Robinson, Ark.

BOHART, ENSIGN R. M., U. S. N. R., Malaria Control Lab., Hadnot Point, New River, N. C.

BRADLEY, G. H., U. S. P. H. S. (R), Atlanta, Ga.

BROWN, CAPT. F. MARTIN, Colorado Springs, Colo.

BUNN, MAJ. RALPH W., 1st Medical General Laboratory, Fort Sam Houston, Tex.

BURKS, 1ST LT. B. D., Sn. C., 12th Malaria Survey Unit, A. P. O. 3658, c/o Postmaster, New York, N. Y.

BUZICKY, 2ND LT. ALBERT, Camp Surgeons Office, Station Hosp., Camp Crowder, Mo.

CAZIER, 1ST LIEUT. MONT A., Sn. C., Lab. Seventh Service Command, Omaha, Nebr.

CHAMBERLAIN, PVT. ROY W., Med. Det. S. C. U. 1968, Reception Center, U. S. Army, Fort Douglas, Utah.

CHRISTENSON, 1ST LT. L. D., 3rd Malaria Survey Unit, New Orleans Staging Area, New Orleans, La.

CONNELL, 1ST LT. WM., Medical Section, 1580 S. U., Camp Campbell, Ky.

COPE, ENSIGN OLIVER B., Malaria Control, Marine Corps Air Station, Cherry Point, N. C.

CURTISS, LT. CHARLES.

DAGGY, LT. (j. g.) RICHARD H., (M. C.) U. S. N. R., M. Division, Navy 212, Fleet Post Office, San Francisco, Calif.

DAHME, PAUL A.

DANIEL, DERRILL M.

DEBACH, PAUL H., U. S. P. H. S., 309 "C" St., Marysville, Calif.

DELEON, PVT. DONALD, M. D. P. S. S. Section, Army Medical Center, Washington, D. C.

DENNING, DONALD G., U. S. P. H. S. (R), 207 Civil Courts Bldg., New Orleans, La.

DODGE, H. RODNEY, U. S. P. H. S., Box 1095, Macon, Ga.

<sup>1</sup>A list of all entomologists in the armed and related services of the United States has been published in the *Journal of Economic Entomology*, 36 (1):146-155, February, 1943.

DORSEY, ENSIGN CARL K., U. S. N. R., Naval Medical School, Bethesda, Md.  
 DORST, MAJ. HOWARD E., Hq. M. R. T. C., Camp Robinson, Ark.  
 DOW, LT. RICHARD, Sn. C., Station Hospital, Camp Cooke, Calif.

EATON, PVT. CHARLES B., 615th T. S. S. (sp.), B. T. C. (5) A. F. F. T. T. C., Kearns, Utah.

ELISHEWITZ, HAROLD, Med. Res. Inst., National Naval Med. Cen., Bethesda, Md.  
 EMERSON, LT. K. C., Fort William McKinley, Rizal, P. I. (Reported missing. Probably prisoner of Japanese.)

FAY, RICHARD W., U. S. P. H. S., New Orleans, La.

FISHER, ELIZABETH, American Red Cross, Washington, D. C.

FISK, CAPT. FRANK W., Med. Sec., S. O. S., A. P. O. 886, care of Postmaster, New York, N. Y.

FLUNO, J. A., U. S. P. H. S., Jefferson City, Mo.

FREEBORN, LT. COL. S. B., Sr. Surgeon, Malaria Control in War Areas, 505 Volunteer Bldg., Atlanta, Ga.

FRONK, 2ND LT. W. DON, School Dept., Fitzsimmons Hospital, Denver, Colo.

GERRY, CAPT. BERTRAM I., Sn. C., M. D. R. P., Camp Robinson, Ark.

GILLOGLY, PVT. LORIN R., Hdq. 80th Inf. Tng. Bn., Camp Roberts, Calif.

GOOD, N. E., U. S. P. H. S. (R), Washington, D. C.

GRESSITT, J. LINSLEY, Prisoner of Japanese at Canton, China.

GRIFFITH, M. E., U. S. P. H. S. (R), Oklahoma City, Okla.

GRIFFITHS, LT. J. T., 24th O. T. B., Carlisle Barracks, Carlisle, Pa.

GURNEY, CAPT. ASHLEY B., 23rd Malaria Survey Unit, Malaria Training Center, N. O. Staging Area, New Orleans, La.

HALL, DAVID G.

HARDEN, PHILIP, U. S. P. H. S. (R), 207 Civil Courts Bldg., New Orleans, La.

HART, LT. THOMAS A., Station Hospital, Camp Gordon, Georgia.

HARDY, CAPT. ELMO D., A. P. O. 629, c/o Postmaster, Miami Fla.

HAUG, LT. GORDON W., (Canadian), 1st Bn., Rocky Mountain Rangers, (C. A.), Colwood Camp, Victoria, B. C.

HEATON, 1ST LT. ROBERT R., Sn. C., 15th Medical General Laboratory, Ft. Sam Houston, Texas.

HERMS, LT. COL. W. B., Army Medical Field Service School, Carlisle Barracks, Pa.

HERTIG, MAJ. MARSHALL, Sn. C., Army Medical Center, Washington, D. C.

HITCHCOCK, PVT. F. C. JOHN D., 4th Platoon, 300th General Hospital, Camp Forrest, Tenn.

HOFFMAN, WM. E., Prisoner of Japanese at Canton, China.

HOLWAY, ENSIGN RICHARD T., U. S. N. R., Naval Medical Center, Bethesda, Md.

HOOGSTRAAL, HARRY, Ft. McPherson, Ga.

HORSFALL, 1ST LT. WM. R., Sn. C., Camp Grant, Ill.

HOWE, 1ST LT. WAYNE L., Sn. C., Army Medical School, Army Medical Center, Washington, D. C.

HURLBUT, LT. HERBERT S., H-V (S), U. S. N. R., Box 36, N. O. B., Guantanamo Bay, Cuba.

HUTCHINS, LT. (j. g.) ROSS E.

JONES, JR., CADET JOSEPH W., A. A. C., P. O. Box 173, Newbern, Tenn.

KECK, CAPT. C. B., A. U. S., Box 340, Honolulu, T. H.

KENT, ELLIS C.

KING, LT. COL. W. V., Laboratory Fourth Service Command, Fort McPherson, Ga.

KLOTS, CAPT. ALEXANDER B., Sn. C., Camp Robinson, Ark.

KNIGHT, ENSIGN KENNETH L., (M. C.) U. S. N. R., Navy 600, c/o Fleet Post Office, San Francisco, Cal.

KNIGIN, TAMARATH, Malaria Laboratory, Office of Sector Surgeon, A. P. O. 868, c/o Postmaster, New York, N. Y.

KRAFCHICK, PVT. BERNARD, General Hospital, Fort Dix, N. J.

KRAMER, CORP. SOL, M. D. P. S. S. S., Army Medical School, Washington, D. C.

- KRETSCHMAR, LT. (j. g.), District Coast Guard Office, 310 N. Washington Square, Philadelphia, Pa.
- KROMBEIN, LT. KARL V., 1318th Service Unit, Post Headquarters, Camp Pickett, Va.
- KUITERT, LT. LOUIS C., Sn. C., Army Air Base, Dyersburg, Tenn.
- LANHAM, PVT. URLESS N., 4th Mapping Squadron, March Field, Riverside, Calif.
- LIVINGSTON, 1ST LT., E. M., Sn. C., Camp Pickett, Va.
- LOWRIE, 2ND LT. RAYMOND E., F. A., Ft. Bragg, N. C.
- LUND, LT. (j. g.) HORACE O., Naval Air Station, Elizabeth City, N. C.
- MACCREARY, LT. (j. g.) DONALD, H-V (S), U. S. N. R., Newark, Del.
- MAINA, 2ND LT. BARTHOLOMEW A., F. A., Btry. B, 345 F. A. Bn., A. P. O. 90, c/o Postmaster, Shreveport, La.
- MANGRUM, PVT. JAMES F., 183 General Hospital, Fort Sill, Okla.
- MANIS, H. C., Air Transport Service, Moscow, Idaho.
- MANZELLI, 1ST LT. MANLIO, Sn. C., Station Hospital, Camp Carrabelle, Fla.
- MARCH, 2ND LT. RALPH B., IV Ground Air Support Command, Army Air Base, Thermal, Calif.
- MARKOS, 1ST LT. BASIL G., Camp Surgeon's Office, Camp Shelby, Miss.
- MASON, LT. COL. HORATIO C., Academic Dept., Infantry School, Ft. Benning, Ga.
- MEAD, CANDIDATE ALBERT R., O. C. S., M. O. C., M. R. T. C., Co. B, Camp Berkeley, Texas.
- MEDLER, ENSIGN, JOHN T., H-V (S), U. S. N. R., Yard Dispensary, Mare Island, Calif.
- MICHENER, 1ST LT. C. D., M. R. P. Station Hosp., c/o Post Medical Inspector, Ft. Dix, N. J.
- MILLIRON, 1ST LT. HERBERT E., 1560 Service Unit, Medical Section, Station Hospital, Camp Atterbury, Ind.
- MUNDELL, R. C. (deceased 1942, while a member of fighting forces in India.)
- MUNSON, SAM C.
- NICHOLSON, H. PAGE, U. S. P. H. S. (R), 300 Essex Bldg., Norfolk, Va.
- NYE, CAPT. W. P., U. S. Marine Corps, Camp Pendleton, Oceanside, Calif.
- OMAN, LT. P. W., Sn. C., Carlisle Medical Center, Carlisle, Pa.
- OWEN, CAPT. WM. B., Carlisle Barracks, Pa.
- PARSONS, CORP. CARL T., Medical Detachment, Hendricks Field, Sebring, Fla.
- PAULLUS, PVT. JAMES, (37408037), Co. G., 2nd C. W. S. Training Regiment, Camp Sibert, Ala.
- PEDERSON, LT. (j. g.) CALVIN E., H-V (S), U. S. N. R., Malaria Control Laboratory, U. S. Naval Air Station, Trinidad, B. W. I.
- PETERS, 1ST LT. HAROLD T., Station Hospital, Camp Pickett, Va.
- PETERSON, ALLAN, U. S. P. H. S. (R), State Board of Health, Jackson, Miss.
- PETRAKIS, PVT. F. C. MANUEL M., Det. Medical Dept., Extension Hosp., Chanute Field, Ill.
- PETTIT, LINCOLN C.
- POST, R. L., Coast Guard, A. S. (R. R.), Bonneville, Ore.
- PRATT, HARRY D., U. S. P. H. S., Assistant Ent. (R), San Juan, Puerto Rico.
- PRITCHARD, A. EARL, U. S. P. H. S., Base Hospital, A. P. O. 848, New York, N. Y.
- REED, LT. W. D., Service Division, Edgewood Arsenal, Md.
- RICHMOND, MAJ. E. A., Technical Division, C. W. S., Bldg. 330, Edgewood Arsenal, Md.
- RIEGEL, 1ST LT. GARLAND T., Sn. C., 12th Malaria Survey Unit, A. P. O. 3658, c/o Postmaster, New York, N. Y.
- RIES, 1ST LT. DONALD T., Sn. C., Camp Grant, Ill.
- RINGS, CORP. ROY W., Hqs. & Hqs. Co., Reception Center F., Fort Harrison, Ind.
- RITCHIE, 1ST LT. CALVIN L., Sn. C., S. C. U. 1947, Station Hospital, Camp San Luis Obispo, Cal.
- ROBERTS, CAPT. R. A., Sn. C., Army Officers Tn. Bn., Carlisle Barracks, Pa.
- ROCKSTEIN, CORP. MORRIS, 35th T. S. S., A. A. F., Pantlind Exhibition Bldg., 5th floor, Grand Rapids, Mich.



RODECK, LT. H. G., A. C. T. T. C., O. T. S., 2609 Collins Ave., Miami Beach, Fla.  
ROSS, LT. E. S., Sn. C., 8th Service Command Laboratory, Ft. Sam Houston,  
Tex.

ROTH, LOUIS M., Laboratory, 4th Corps Area, Ft. McPherson, Ga.  
RYAN, PVT. GEORGE S., Btry. C-399 CA, B. B. Bn., Sault Ste. Marie, Mich.

SCHOOFF, H. F., U. S. P. H. S. (R.), Raleigh, N. C.  
SCHROEDER, CAPT. PHILIP M., R. O. T. C., University of Minnesota, Minneapolis,  
Minn.

SHIELDS, LT. S. E., Sn. C., Key West Barracks, Fla.  
SMITH, MAJ. GORDON E., U. S. P. H. S. (R), A. P. O. 689, c/o Postmaster, New  
York, N. Y.

SPENCER, LT. COL. HERBERT, Sn. C., School of Military Government, Charlottes-  
ville, Va.

SPIETH, 1ST LT. HERMAN T., A. C. Roney Plaza, Miami Beach, Fla.  
STAINS, ENSIGN GEORGE S., District Medical Office, 14th Naval District, Pearl  
Harbor, T. H.

STEARNS, MAJ. L. A., Sn. C., Hq. Ninth Air Force, Bolling Field, D. C.  
STONE, 1ST LT. PHILIP C., Sn. C., Norfolk Army Base, Va., H. R. P. E.  
STRICKLAND, E. H., No. 133, Can. Army Basic Tn. Cen., Prince of Wales Armory,  
Edmonton, Alberta, Can.

TARSHIS, SGT. IRVIN, 143rd Station Hospital, Camp Bowie, Texas.  
THATCHER, CAPT. T. O. (0-305-165), Hq. 495 C. A. & Br. (A. A.), A. P. O. 860, c/o  
Postmaster, New York, N. Y.

TING, ENSIGN PETER, U. S. N. R.  
TRAUB, 1ST LT. ROBERT, Sn. C., 9th Malaria Survey Unit, New Orleans Staging  
Area, New Orleans, La.

TUCK, PVT. J. B., O. C. P. S., Det. M. R. T. C., Co. B, Camp Berkeley, Texas.  
TULLOCH, LT. (j. g.) GEO. S.

USINGER, R. L., U. S. P. H. S. (R), Atlanta, Ga.

VOGT, G. B., U. S. P. H. S., College Park, Md.

WALLACE, CORP. GEO. E., Co. K, ER 8, Enlisted Students Bn., Student Rgt. T. D.  
School, Camp Hood, Tex.

WENZEL, 1ST LT. R. L., Sn. C., 707th Med. Sn. Co., Ft. George G. Mead, Md.  
WEST, 2ND LT. WM. R., 14th R. O. C., M. C. S., Co. B, Barracks B, Quantico, Va.  
WESTFALL, JR. PVT. MINTER J., Med. Sec. S. C. U. No. 1948, Camp Santa Anita,  
Arcadia, Calif.

WILSON, LT. JOHN W., M. C., Wellston Air Depot, Macon, Ga.

WIRTH, M. W., U. S. P. H. S. (R), P. O. Box 521, Lake Charles, La.

WOKE, LT. PAUL A., U. S. N. R., Navy 213, care of F. P. O., New York, N. Y.

WOOD, PVT. STEPHAN L., Btry. D, 28th Bn., 7th Reg. F. A., R. T. C., Ft. Sill,  
Okla.

WORTHLEY, MAJ. H. N., C. W. S., R. T. C., Camp Sibert, Ala.

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NEW SPECIES OF HALICTOPHAGUS WITH A KEY TO  
THE GENUS IN NORTH AMERICA

(Strepsiptera, Halictophagidae)

RICHARD M. BOHART,

University of California,  
Los Angeles, California

Since the publication of the writer's revision of the Strepsiptera<sup>1</sup> enough material has been studied, principally through the cooperation of P. W. Oman, of the U. S. National Museum, to warrant a synopsis of the genus *Halictophagus* Curtis. A generic synonymy has been previously published.<sup>1</sup> The genus is characterized as follows:

Parasites of leafhoppers, fulgorids, and treehoppers. Distribution world-wide.

*Male*.—Antenna seven-segmented, the last five segments laterally flabellate, compact, basal portion of the segments less than three times as long as broad; tibiae differentiated into a pseudo-segment near the base; tarsi three-segmented.

*Female*.—Head comprising half to two-thirds of the cephalothorax; mandible with one or two apical teeth; first abdominal sternite with more or less definite pigmented area connected with the cephalothorax; abdomen with one to four genital openings.

Satisfactory determination of *Halictophagus* can be made only from specimens properly mounted on microscope slides. The writer has had good success soaking the abdomen of the host overnight in cold 5 per cent potassium hydroxide; dissecting out the parasite; washing it for several hours in water; dehydrating it by successive 15-minute baths in 25 per cent, 50 per cent, 75 per cent, and 95 per cent alcohol; and mounting it directly in euparal or through clove oil into balsam. Females should be mounted ventral side up. To avoid crushing the male, the coverslip can be raised on broken pieces of coverslip to the desired height, or circles or bristle-board previously impregnated with the mounting medium can be used. The male aedeagus should first be dissected off and mounted on its side under a separate coverslip.

<sup>1</sup>Bohart, R. M. 1941. A revision of the Strepsiptera with special reference to the species of North America. Univ. Calif. Pub. Ent., 7: 91-160.

In addition to properly mounted material it is always desirable to have a series of specimens for purposes of identification. This is particularly true with respect to the females, many of whose characters are relatively unstable. It has been the practice in the past to depend to a large extent on the identity of the host to determine the parasite. While it is true that a species of *Halictophagus* will usually confine its attack to related host species, the exceptions are so numerous as to make the application of this principle unreliable.

Holotypes and allotypes of new species herein described are deposited in the U. S. National Museum.

### KEY TO THE SPECIES OF HALICTOPHAGUS IN AMERICA NORTH OF MEXICO

#### MALES

1. Aedeagus rounded before the apex, not sharply angular or barbed; antenna compact. . . . . **barberi**
- Aedeagus sharply angled before the apex, not rounded. . . . . 2
2. First two antennal segments and terminal palpal segment without conspicuous, large sensoria; scutellum approaching a triangle in outline; compound eye with 30 to 40 facets visible in dorsal aspect; middle and hind tibiae not appreciably excavated externally. . . . . 3
- One or both of first two antennal segments, and terminal palpal segment with conspicuous, large sensoria; compound eye with only 15 to 20 facets visible in dorsal aspect; middle and hind tibiae excavated at least a third of their length from the external apex. . . . . 5
3. Front femur with a tooth-like inner basal angle. . . . . **insularum**
- Front femur rounded toward the inner base. . . . . 4
4. Head more than four times as wide as the eye length; body about 2 mm. long to apex of postscutellum. . . . . **omani**
- Head less than four times as wide as the eye length; body about 1 mm. long to apex of postscutellum. . . . . **americanus**
5. First antennal segment, basal palpal segment, all femora, and front tibia with large sensoria; scutellum short, approaching a rectangle; flabellae of third and fourth antennal segments well separated. . . . . **bidentatus**
- First antennal segment, basal palpal segment, and legs without large sensoria. . . . . 6
6. Front tibia with a stout, sharp basal spine; terminal segment of palpus rounded apically. . . . . **mackayi**
- Front tibia without a basal spine. . . . . 7
7. Prescutum, scutellum and postlumbium all of about equal length; front femur with a basal angle; segments of palpus about equal in length, the terminal one with large sensoria on apical half only. . . . . **oncometopiae**
- Prescutum, scutellum, and postlumbium of unequal length. . . . . 8
8. Scutellum approaching a rectangle, front margin almost straight; front femur with a distinct basal angle or hump; terminal palpal segment about twice as long as broad; aedeagus strongly two pronged (fig. 38), . . . . . **serratus**
- Scutellum with front margin strongly convex; front femur rounded basally; terminal palpal segment about six times as long as broad, tapering to a point apically; aedeagus with only one prong (fig. 32). . . . . **acutus**

#### MALE CEPHALOTHECAE

1. Upper margin of mouth area with a definite median lip-like area which is much thicker than the mouth rim proper. . . . . 2
- Upper margin of mouth area convexly but evenly thickened toward the middle; lip-like area when present not much thicker than mouth rim proper. . . . . 5
2. Upper margin of mouth area continued in a relatively smooth unbroken line to the outer edges of the mandibles. . . . . **mackayi**

- Upper margin of mouth incomplete or at least very irregular beyond the inner edges of the mandibles.....3
3. Mandible with two distinct teeth which ordinarily do not surpass the apical margin; antenna represented by a clear oval spot surrounded by a darker ring.....*oncometopiae*  
Mandible usually with one or more small teeth, sometimes appearing as serrations; antenna usually represented by an irregular dark spot.....4
4. Maxillary area hardly half as long as clear area below mandibles....*serratus*  
Maxillary area much more than half as long as clear area below mandibles,.....*acutus*
5. Lower margin of mouth subtending a darkly pigmented area which tapers almost to a point.....*omani*  
Lower margin of mouth not subtending a darkly pigmented, pointed area....6
6. With a nearly complete arched thickening over the mandibles above and separate from the upper mouth margin.....*bidentatus*  
Without a thickening above the upper mouth margin.....7
7. Apical mandibular tooth large and sharp; upper margin of mouth area with a small but distinct anterior lip-like area.....*insularum*  
Apical mandibular tooth small or dull.....8
8. Upper margin of mouth area without anterior thickening.....*americanus*  
Upper margin of mouth area with a distinct anterior lip-like projection,.....*serratus*

## FEMALES

1. Mandible with a single tooth located at inner apex.....2  
Mandible with two large teeth at inner apex or with one large tooth followed by a series of smaller projections.....8
2. Basal collar<sup>1</sup> approximating cephalothorax in size and shape or smaller; but in reverse position (see figs. 7, 8).....3  
Basal collar broad and cape-like, not resembling cephalothorax in size and shape (see figs. 4, 5, 9); abdomen with three genital openings.....5
3. Mandible with a hump opposing the apical tooth.....*uhleri*  
Mandible without a hump opposing the apical tooth.....4
4. Pigmentation of thorax much darker than that of head; basal collar approximating cephalothorax in size; spiracles placed close to lateral head lobes; abdomen with three genital openings.....*mackayi*  
Pigmentation of thorax similar to that of head; basal collar much smaller than cephalothorax; spiracles placed far posterior to lateral head lobes; lateral thoracic margin with a distinct internal thickening midway between lateral head lobe and spiracle; abdomen with two genital openings.....*callosus*
5. Basal collar less heavily pigmented than cephalothorax.....6  
Basal collar at least as heavily pigmented as cephalothorax.....7
6. With a heavily pigmented band along the anterior margin of the brood passage opening at base of the head.....*insularum*  
Without a distinct heavily pigmented band along brood passage opening; mandible with a hump opposing the single large tooth.....*americanus*
7. Basal collar hardly more heavily pigmented than cephalothorax; cephalothorax about as long as broad.....*obtusae*  
Basal collar much more heavily pigmented than cephalothorax; cephalothorax distinctly broader than long.....*omani*
8. Mandibles with two large distinct teeth at inner apex.....9  
Mandible with a single large tooth and a series of subsidiary teeth.....10
9. Basal collar nearly uniform in color and posteriorly pointed; cephalothorax distinctly longer than broad; abdomen with three genital openings,.....*bidentatus*  
Basal collar with a dark central portion and rounded posteriorly; cephalothorax hardly longer than wide; abdomen with two genital openings,.....*oncometopiae*

<sup>1</sup>All female *Halictophagus* seen by the writer have a collar-like or cape-like pigmented area on the first abdominal sternite continuous with the cephalothorax.

10. Head with a distinct median apical lobe; mandible with a hump opposing the large apical tooth and separated from the latter by a series of small irregularities or teeth; cell-like reticulations of basal collar moderate in size; abdomen with two genital openings. . . . . **acutus**  
 Head with a weakly defined median apical lobe; mandible with a series of teeth at the apex but with no opposing hump; cell-like reticulations of basal collar relatively large, some of them approaching spiracles in size; abdomen with one genital opening. . . . . **serratus**

***Halictophagus americanus* Perkins**

Figures 5, 26, 37

*Halictophagus americanus* Perkins, 1905. Hawaiian Sugar Planters' Exp. Sta. Bul. 1: 105.

*Agalliaphagus americanus* Pierce, 1908. Proc. Ent. Soc. Wash. 9: 80.

*Agalliaphagus uhleri* Pierce, 1918. Proc. U. S. Nat. Mus. 54: 479 (not *uhleri* Pierce, 1909).

This species resembles *omani* and *insularum* in many respects. It parasitizes many species of *Aceratagallia* in North America. However, a male and female studied from *Aceratagallia neosignata* Oman<sup>3</sup>, Guitrache, Argentina, belong to an entirely different species, resembling *acutus*.

**Material Studied.**—Holotype female (USNM), on *Aceratagallia 4-notata* (Prov.), Columbus, Ohio; 1 female, on *A. uhleri* (Van Duzee), Rocky Ford, Colorado; 3 females, on *A. sanguinolenta* (Prov.), Scott Co. and Oregon Co., Missouri, and Peach Co., Georgia; 2 males and 2 females on *A. helveola* Oman, Garnett, Kansas; 2 females, on *A. accola* Oman, Annapolis, Maryland; 1 male and 1 female, on *A. vastitatus* Oman, Leeds, Utah; 4 females, on *A. fuscicornis* Oman, Tuttle and Hagerman, Idaho; 2 females, on *A. californica* (Bak.), Oregon; 2 females, on *A. curta* Oman, Santa Rita Mts., Arizona; 1 female, on *Aceratagallia* species, Perris, California; 2 males, on *Eutettix tenellus* (Bak.), Mills, Utah and Berger, Idaho.

***Halictophagus insularum* (Pierce)**

Figures 9, 24, 34

*Dioxocera insularum* Pierce, 1908. Proc. Ent. Soc. Wash. 9: 84.

*Dioxocera insularum* Pierce, 1918. Proc. U. S. Nat. Mus. 54: 466.

*Halictophagus insularum* Bohart, 1941. Univ. Calif. Pub. Ent. 7: 148.

*Dioxocera insularum vincenti* Pierce, 1941. Bull. So. Calif. Acad. Sci. 40: 4.

*Dioxocera argentiniae* Pierce, 1941. Bull. So. Calif. Acad. Sci. 40: 5.

*Dioxocera comstocki* Pierce, 1941. Bull. So. Calif. Acad. Sci. 40: 6.

*Dioxocera comstocki elsegundinis* Pierce, 1941. Bull. So. Calif. Acad. Sci. 40: 10.

As recently pointed out by Pierce<sup>4</sup>, the original description was based on an immature and imperfect male specimen mounted on its side in balsam. The uppermost antenna had lost the terminal three segments. This circumstance led Pierce in 1908 to erect a separate superfamily and family for the species. The imperfection was discovered by the writer when examining the type specimens in 1937.

<sup>3</sup>Determinations of the Nearctic and Neotropical leafhoppers mentioned in this paper were made by P. W. Oman.

<sup>4</sup>Pierce, W. D. 1941. A strepsipterous parasite of a leafhopper with descriptions of related species from the same host genus. Bull. So. Calif. Acad. Sci. 40: 1-10.

*H. insularum* appears to attack *Xerophloea viridis* (Fabr.) in various parts of the Western Hemisphere. Specimens from widely separated localities bear a close similarity. In a recent paper Pierce has described and figured a new species and subspecies on *X. viridis* (*Diozocera insularum vincenti* from St. Vincent, West Indies; *D. argentiniae* from Cacarana, Argentina). At the same time he described a new species and subspecies on *X. vanduzeei* Lawson (*Diozocera comstocki* from W. Anacapa Island, California; *D. comstocki elsegundinis* from El Segundo, California). Of these, *vincenti* was described from a single female, *argentinae* from an imperfect female and a male cephalotheca, *comstocki* from two immature male pupae, and *elsegundinis* from a single imperfect female. From Pierce's illustrations and descriptions these additional names do not seem to be warranted. They are therefore tentatively placed in synonymy until more specimens are discovered.

**Material Studied.**—Holotype male and allotype female, Grenada, West Indies; 2 females, Salt Lake City, Utah, July 13, 1935 (P. W. Oman); 1 male and 4 females, Davis, California, Aug. 30, 1931 (H. C. Donohoe); 1 male (figs. 24, 34) Medio Agus, Province of San Juan, Argentina, Nov. 17, 1926 (C. F. Henderson); 1 female, Bahia Blanca, Argentina, Feb. 8, 1927 (C. F. Henderson).

### ***Halictophagus omani* new species**

Figures 4, 16, 21, 31, 45

This species is closely related to *americanus* but can be separated by the characters given in the key. I take pleasure in naming it for P. W. Oman whose interest has made this study possible.

**Male.**—Antenna moderately compact, segments 3–6 with basal lengths nearly equal, first two segments with scattered small sensoria; mandible tapering gradually to a point, terminal palpal segment very slender but shorter than mandible and with inconspicuous sensoria; compound eye with about 30 facets visible in dorsal aspect; mesothoracic prescutum short and transverse, about a third as long as pronotum; metanotum as shown in figure 21; front tibia four times as long as wide at apex, with a bump near inner base; front metatarsus broad pyriform in outline; middle coxa about three-quarters as long as middle femur; second to fifth sternites with paired median pigmented spots partially fused, sixth to eighth sternites with single large median spots; aedeagus as in figure 31. Length of antenna 0.546 mm., breadth of head 0.770 mm., length of metanotum 1.246 mm.

**Male Cephalotheca.**—Proportions and pigmentation as in figure 45. Upper mouth margin not reaching mandibles laterally and with a slight median lip-like thickening; mandible with a large apical tooth opposed by a prominent hump. Breadth of cephalotheca 0.840 mm., height 0.574 mm.

**Female.**—Cephalothorax amber-colored, basal collar dark brown. Mandible with a large sharp apical tooth opposed by a moderate hump; brood passage opening with a thick lip-like margin, connected with lateral margins of cephalothorax by thickenings; basal collar cape-like, two-thirds as long as cephalothorax. Length of cephalo-

thorax 0.441 mm., length to brood passage opening 0.182 mm., breadth at spiracles 0.546 mm., breadth at base 0.483 mm.

*First Larva*.—Length excluding stylets 0.199 mm., stylets about two-thirds as long as rest of body.

*Material Studied*.—Parasites of *Oncometopia lateralis* (Fabr.): Holotype male, allotype female, and 1 male and 6 female paratypes, Howard Co., Arkansas, Sept. 27, 1937 (W. F. Turner). Other paratypes: 1 female, Athabasca River, Alberta (M. Cary); 5 females, Columbia, South Carolina, Sept. 27, 1935 (O. Cartwright); 5 females, Clemson College, South Carolina, May, 1928 (B. B. Pepper and H. G. Davis); 1 female, Jasper Co., Georgia, Sept. 2, 1936 (W. F. Turner); 1 female, Coolidge, Georgia, May 15, 1916 (W. D. Pierce); 1 female, Quincy, Florida, Oct. 27, 1905 (W. A. Hooker); 1 female, Roane Co., Tennessee, Sept. 14, 1937 (W. F. Turner); 2 males and 7 females, Hamilton Co., Tennessee, April, 1940 (W. F. Turner); 1 female, Bossier Park, Louisiana, Oct. 28, 1937 (W. F. Turner). 1 female, Tyler, Texas, May 5, 1906 (F. C. Pratt); 1 female, Denison, Texas, March 29, 1939 (L. S. Jones); 1 female, Lawrence Co., Arkansas, April 14, 1923 (B. C. Marshall); 1 female, Elkins, New Mexico, July 16, 1936 (R. H. Beamer); 1 female, Chiricahua Mts., Arizona (H. G. Hubbard); 5 females, North of Palmdale, California, June 8, 1935 (P. W. Oman); 1 female, Riverside Co., California, July, 1935. Three female metatypes, Cochise Co., Arizona, July 29, 1927 (R. H. Beamer) on *Oncometopia* species near *lateralis* (F.) Paratypes in collections of U. S. National Museum, University of Kansas, Harvard Museum of Comparative Zoology, California Academy of Sciences, and the writer.

### *Halictophagus obtusae* new species

This species is similar in many respects to *americanus* and *omani*. It differs primarily in the pigmentation and greater length of the cephalothorax. It is also a larger species.

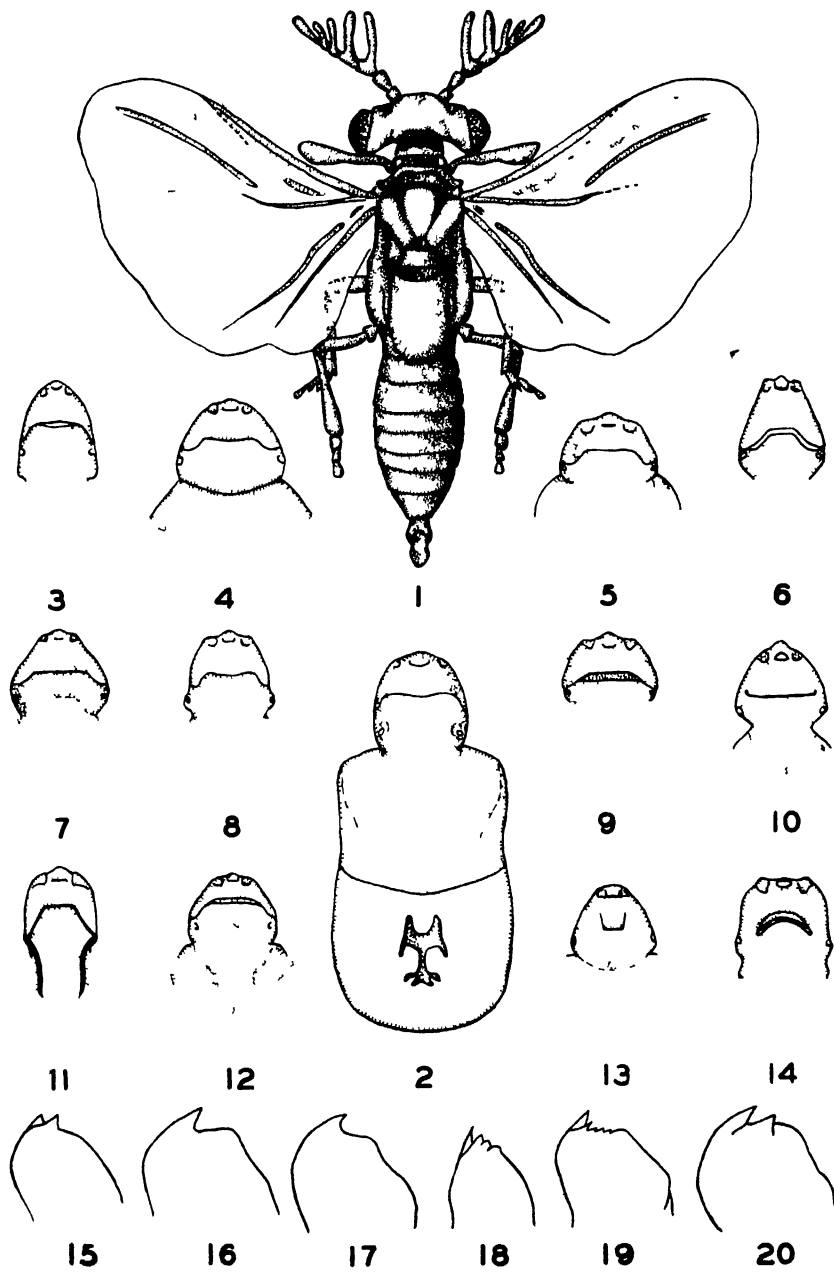
*Female*.—Cephalothorax amber-brown, basal collar slightly darker, especially toward the base. Mandible with a large apical tooth opposed by a moderate hump, outer margin hardly undulate; brood passage opening with a moderate lip-like thickening, connected by thickenings to lateral margins of cephalothorax; spiracles adjacent to hind margin of head; basal collar cape-like, with transverse striae, about two-thirds as long as cephalothorax. Abdomen with two genital openings. Length of cephalothorax 0.7 mm., length to brood canal opening 0.294 mm., breadth at spiracles 0.7 mm., breadth at base 0.476 mm.

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### EXPLANATION OF PLATE I

(Camera lucida drawings corrected for asymmetry.)

Figure 1, *Halictophagus serratus* male. 2, *serratus* female, ventral. 3-14, ventral view of female cephalothorax and basal collar. 3, *bidentatus*. 4, *omani*. 5, *americanus*. 6, *acutus*. 7, *mackayi*. 8, *uhleri*. 9, *insularum*. 10, *oncometopiae*. 11, *membraciphaga*. 12, *piperi*. 13, *chinensis*. 14, *gressitti*. 15-20, female mandible, left ventral view. 15, *bidentatus*. 16, *omani*. 17, *uhleri*. 18, *serratus*. 19, *acutus*. 20, *gressitti*.





Holotype female and 1 female paratype, Paso Ancha, San Sebastian, Costa Rica, March 11, 1936 (C. H. Ballou); on *Oncometopia obtusa* (L.). Paratype in author's collection.

### ***Halictophagus oncometopiae* (Pierce)**

Figures 10, 27, 39

*Dacrytocara oncometopiae* Pierce, 1918. Proc. U. S. Nat. Mus. 54: 473.

*Dacrytocara undata* Pierce, 1918. Proc. U. S. Nat. Mus. 54: 474.

*Halictophagus oncometopiae* Bohart, 1941. Univ. Calif. Pub. Ent. 7: 150.

The holotype male in the U. S. National Museum was extracted from its puparium in a specimen of *Oncometopia undata* (Fabr.) misidentified as *O. lateralis* (Fabr.). The species described by Pierce as *Dacrytocara undata* from *O. undata* was based on two females which undoubtedly belong to *oncometopiae*.

The species is distinctive in many ways as figured and outlined in the key. No close relationship is shown toward *omani* and *obtusae* which parasitize other species of *Oncometopia*.

**Material Studied.**—On *O. undata* (F.): Male puparium, Bladensburg, Maryland; male puparium, Southern Pines, North Carolina; male puparium, Meredith, South Carolina; male puparium and 5 females, Clemson College, South Carolina; holotype male (USNM), Egypt, Georgia; cotype female (USNM), Thomasville, Georgia; 1 male and an empty puparium, Hamilton Co., Tennessee; male puparium, Utica, Mississippi; 1 female, Lincoln, Mississippi; 2 females, Jackson, Alabama; 2 male puparia, Mound, Louisiana; 2 male puparia and 1 female, Opelousas, Louisiana; 2 male puparia and 1 female, Tallulah, Louisiana; 1 female, Greenville, Texas; 1 male, Siloam Springs, Arkansas; 1 female, Durant, Oklahoma. On species near *O. undata* (Fabr.): 2 male puparia and 1 female, Florida.

### ***Halictophagus uhleri* (Pierce)**

Figures 8, 17

*Pentagrammaphila uhleri* Pierce, 1909. Bull. U. S. Nat. Mus. 66: 169 (not *Agalliphagus uhleri* Pierce, 1918).

*Halictophagus uhleri* Bohart, 1941. Univ. Calif. Pub. Ent. 7: 150.

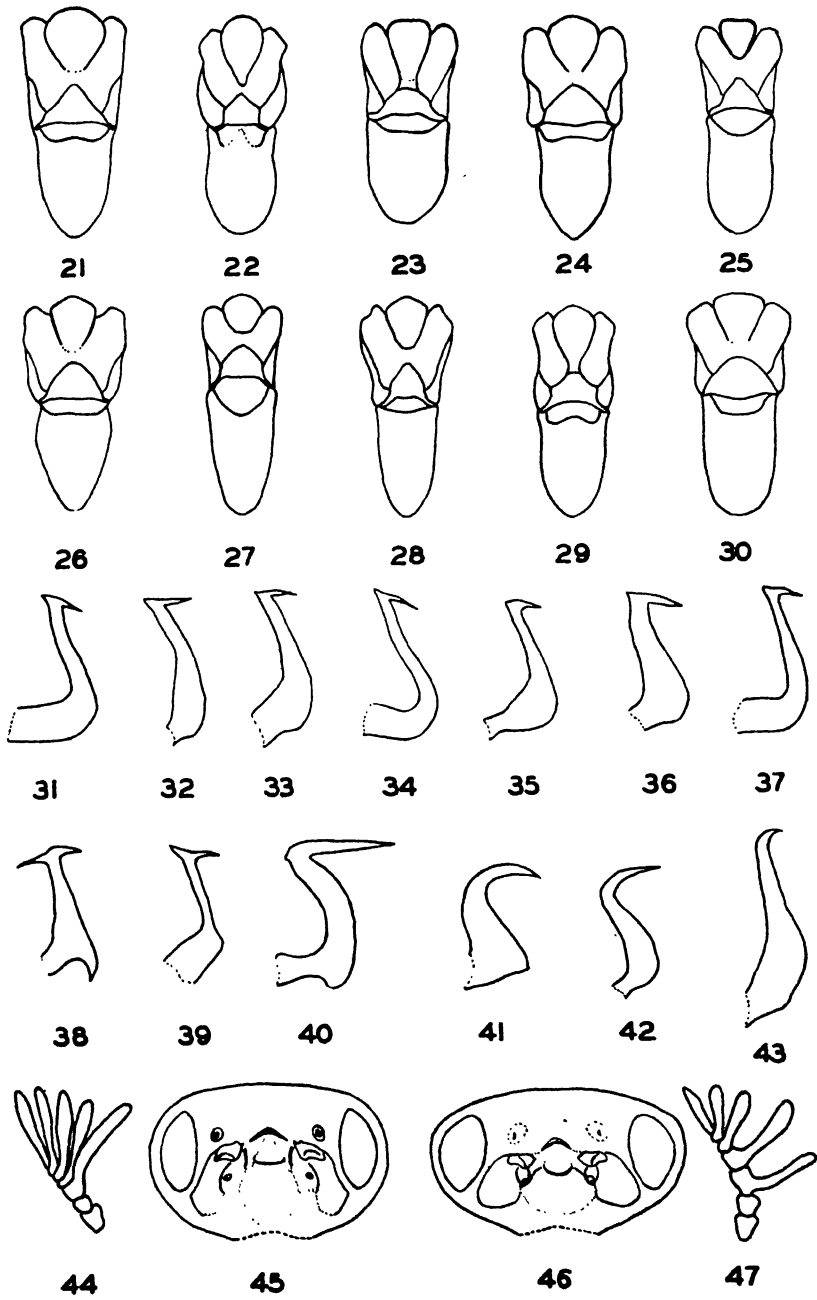
This species is known only from the female holotype at the U. S. National Museum. Although it was placed by Pierce in the family Elenchidae, it is a typical halictophagid.

**Material Studied.**—Holotype female on *Pentagramma vittifrons* Uhler, "Dacota."

## EXPLANATION OF PLATE II

(Camera lucida drawings corrected for asymmetry.)

Figures 21-30, dorsal view of male metathorax. Figure 21, *omani*. 22, *acutus*. 23, *bidentatus*. 24, *insularum*. 25, *mackayi*. 26, *americanus*. 27, *oncometopiae*. 28, *australensis*. 29, *piperi*. 30, *membraciphaga*. 31-42, lateral view of aedeagus. 31, *omani*. 32, *acutus*. 33, *bidentatus*. 34, *insularum*. 35, *mackayi*. 36, *schwarzii* Perkins. 37, *americanus*. 38, *serratus*. 39, *oncometopiae*. 40, *piperi*. 41, *membraciphaga*. 42, *barberi*. 43, *chinensis*. 44, *piperi*, male antenna. 45, *omani*, male cephalotheca. 46, *serratus*, male cephalotheca. 47, *bidentatus*, male antenna.



***Halictophagus barberi* (Pierce)**

Figure 42

*Anthericomma barberi* Pierce, 1908. Proc. Ent. Soc. Wash. 9: 84.*Halictophagus barberi* Bohart, 1941. Univ. Calif. Pub. Ent. 7: 147.

The single male, without host data, on which this species was based, was redescribed and figured by Pierce (1909. Bull. U. S. Nat. Mus. 66). When the writer examined the type specimen in 1937, it had been remounted in balsam and was partially broken. It should be noted that the figure of the metanotum given by Pierce in 1909 is somewhat in error. The prescutum should be shorter and less angular, the scutellum proportionately larger and more pointed in front, and the interscutal area much more prominent. Also the antennae are more compact than is shown in Pierce's figure and an additional vein is present in the vannal area of the wing. The remounting process made it possible to study the aedeagus, which is transitional in type to that of *membraciphaga*, and entirely unlike that of any other known North American species.

**Material Studied.**—Holotype male (U. S. National Museum), Santa Fe, New Mexico; host unknown.

***Halictophagus mackayi* (Bohart)**

Figures 7, 25, 35

*Pseudopatella mackayi* Bohart, 1937. Pan-Pac. Ent. 13: 103 (Types, CAS).*Halictophagus mackayi* Bohart, 1941. Univ. Calif. Pub. Ent. 7: 147.

The distinctively spined tibiae of the front legs of the male are a unique characteristic of this species. The heavy broad upper margin of the mouth area in the male cephalotheca was not correctly figured in the original description. It should extend to the outside of the mandibles.

**Material Studied.**—Five males and 15 females (type series), on *Deltocephalus* (*Ribautiella*) *affinis* G. & B., Saskatchewan, Canada (M. MacKay). According to correspondence from Margaret MacKay, other hosts of this species in Saskatchewan are *Athysanella acuticauda* (Bak.), *Laevicephalus uhleri* Oman, and *Aconura* species.

***Halictophagus callosus* new species**

Only the female of this species is known. It is characterized by the length of the cephalothorax, the single-toothed mandibles, the peculiar callous above the spiracles, and the inconspicuous basal collar.

**Female.**—Cephalothorax deep amber, basal collar very pale. Cephalothorax longer than broad, front margin of head with a median lobe; mandible with a single apical tooth, broad, outer edge evenly rounded; lateral margin of cephalothorax with an internal knot-like thickening in the middle of the relatively long space between lateral head lobe and spiracle; basal collar semicircular, about half as long as cephalothorax; abdomen with two genital openings. Length of cephalothorax 0.322 mm., length to brood canal opening 0.077 mm., breadth at spiracles 0.287 mm., breadth at base 0.224 mm.

**First Larva.**—Length excluding stylets 0.245 mm., stylets about half as long as rest of body.

Holotype female and 2 female paratypes, Cottonwood Flats, Mt. Rainier, Washington, July 7, 1935 (P. W. Oman); 1 female paratype, Dixie, Washington, June 13, 1937 (R. M. Bohart); on *Idiocerus* species. Paratypes in collections of California Academy of Sciences and the writer.

### **Halictophagus bidentatus** Bohart

Figures 3, 15, 23, 33, 44

*Halictophagus bidentatus* Bohart, 1941. Univ. Calif. Pub. Ent. 7: 147.

The antennae of *bidentatus* represent the most extreme modification yet recorded for the genus. Numerous large sensoria appear on the first two antennal segments and also on the legs.

**Material Studied.**—Two males and two females (including holotype and allotype in U. S. National Museum), Granger, Utah, on *Athysanella utahne* Osborne; 1 male and 3 females, Turkey Creek, Arizona, on *Flexamia flexulosa* Ball; 2 males and 6 females, Vonda, Saskatchewan, Canada, on *Euscelis frigidus* Ball, and *Deltocephalus* (*Ribautiella*) *affinis* G. and B. (host data of Canadian specimens furnished by the collector, Margaret MacKay).

### **Halictophagus serratus** new species

Figures 1, 2, 18, 38, 46

The male of this species is especially notable for its angled scutellum and two pronged aedeagus, and the female for its distinctive mandibles and single genital opening.

**Male.**—General structure as in figure 1. Antenna with segments 3 and 4 unusually lengthened basally, segment 2 with about a dozen large sensoria on its ventral surface; mandible short, less than three times as long as broad, tapering to a point; terminal palpal segment about as long as mandible and pointed apically, inserted near base of first segment, covered with large sensoria; eye with about twelve facets visible dorsally; mesothoracic prescutum small, broadly U-shaped; front femur with a rounded basal angle, front tibia about five times as long as its greatest breadth; front metatarsus pyriform; middle coxa nearly as long as middle femur; hind coxa more than half as long as hind femur; second abdominal sternite with a pair of small pigmented spots, segments 3 to 7 with single small V-shaped median spots; aedeagus as in figure 38. Length of antenna 0.392 mm., breadth of head 0.448 mm., length of metanotum 0.546 mm.

**Male Cephalotheca.**—General proportions as in figure 46. Upper mouth margin with a small lip-like median thickening, extending in a broken line beyond mandibles; mouth area about as high as breadth of lower margin; mandible narrow, apically serrate. Breadth of cephalotheca 0.462 mm., height 0.294 mm.

**Female.**—Cephalothorax amber-colored, deeper along sides of head, with a pale band in front of brood canal opening, basal collar pale amber. Mandible apically serrate; metasternal area and basal collar covered with cell-like reticulations some of which approach spiracles in size; basal collar at least as large as cephalothorax and

apically pointed. Length of cephalothorax 0.182 mm., length to brood passage opening 0.084 mm., breadth at spiracles 0.189 mm., breadth at base 0.161 mm.

Holotype male, allotype female, and 16 female paratypes, Princeton, New Jersey, 1940 (L. M. Black); 1 male and 1 female paratype, Hamilton Co., Tennessee, August, 1939 (W. F. Turner); 1 male paratype, Logansport, Louisiana, July 6 (W. D. Pierce); on *Agallia constricta* V. D. Paratypes in collections of U. S. National Museum, Harvard Museum of Comparative Zoology, California Academy of Sciences, and the author.

### ***Halictophagus acutus* new species**

Figures 6, 19, 22, 32

This species is easily separated by the characters given in the key. Additional diagnostic characters in the male are the long basal constriction of the front and middle femora, the indented posterior margin of the postlumbium, and the narrow, hairy mandibles.

*Male*.—Antenna moderately compact, segments 3 and 4 slightly longer basally than those following, third segment spoonshaped, second segment abundantly supplied with large sensoria; terminal palpal segment about six times as long as broad, three times as long as first, covered with large sensoria; mandible slender, outer edge haired for two-thirds of its length; eye with about ten facets visible in dorsal aspect; mesoprescutum longer medially than pronotum; metanotum as in figure 22, postlumbium with an irregularly indented posterior margin; coxa, femur, and tibia of front leg of about equal length, front metatarsus broad ovate; front and middle femora with a long basal constriction; middle femur and tibia distinctly longer than middle coxa; apical three-quarters of middle and hind tibiae excavated externally; hind coxa about half as long as hind femur; abdominal sternites 2-7 with a pair of pigmented spots, the last five pairs broadly fused; aedeagus as in figure 32. Length of antenna 0.49 mm., breadth of head 0.546 mm., length of metanotum 0.798 mm.

*Male Cephalotheca*.—Upper mouth margin with a very prominent lip-like projection, extending laterally to inner edge of mandibles; mouth area distinctly higher than breadth of lower margin; mandible finely serrate apically. Breadth of cephalotheca 0.546 mm., height 0.336 mm.

*Female*.—Cephalothorax amber-colored, basal collar light brown. Cephalothorax longer than broad, with a distinct median apical lobe; head about as long at middle as rest of cephalothorax; mandible with a sharp apical tooth opposed by a hump, the intervening space filled with small sharp teeth; margin of brood passage opening without conspicuous thickening, connected by thickenings to sides of cephalothorax and roughly similar to it in shape. Length of cephalothorax 0.294 mm., length to brood passage opening 0.161 mm., breadth at spiracles 0.259 mm., breadth at base 0.196 mm.

*First Larva*.—Length excluding stylets 0.259 mm., stylets about half as long as rest of body.

Holotype male, allotype female, and 1 female paratype, Hamilton Co., Tennessee, Sept. 4, 1939 (W. F. Turner); 1 female paratype, Audubon Park, Louisiana, July 18, 1913, on sugar cane (U. C. Loftin); on *Draeculacephala mollipes* (Say). One male paratype, Atzacapozalco, Mexico, Aug. 20, 1921, on *Draeculacephala minerva* Ball. Five female paratypes, Washington, D. C., Nov. 17, 1929 (W. H. Ball); 4 female paratypes, Adams Co., Pennsylvania, September 23, 1938 (W. F. Turner); on *Draeculacephala* species. Paratypes in collections of U. S. National Museum, California Academy of Sciences, and the writer.

## ANNOTATED LIST OF THE EXOTIC SPECIES OF HALICTOPHAGUS

### ***Halictophagus curtisii* Curtis**

*Halictophagus curtisii* Curtis, 1832. British Entomology 3: 433.

Curtis described and figured *curtisii* but ascribed the authorship to Dale who presumably had the species in manuscript. The third and fourth segments of the antennae are not as short as in many of the species of the genus, but are similar to those of *serratus*. Only the male is known. Locality, England; host unknown.

### ***Halictophagus cladoceras* (Jeannel)**

*Tettigoxenos cladoceras* Jeannel, 1913. Voyage de Ch. Alluad et R. Jeannel en Afrique Orientale. Insects Strepsipteres, pp. 1-8.

From Jeannel's description the antennae are of the compact type, the aedeagus is slender with barbed apex, the prescutum is triangular, and the scutellum is transverse pentagonal. Only the male is described.

Locality, British East Africa; host unknown.

### ***Halictophagus australensis* Perkins**

Figure 28

*Halictophagus australensis* Perkins, 1905. Hawaiian Sugar Planters' Assn. Exp. Sta. Bull. 1: 103.

*Pentoxera australensis* Pierce, 1908. Proc. Ent. Soc. Wash. 9: 81.

*Pentozocera australensis* Pierce, 1918. Proc. U. S. Nat. Mus. 54: 474.

Figures of both sexes were given by Perkins. The male antennae are greatly compressed. The original drawing of the metanotum is from the holotype specimen in the U. S. National Museum.

Locality, Australia (Queensland); host, *Tettigonia parthaon* Kirkaldy.

### ***Halictophagus phaeodes* Perkins**

*Halictophagus phaeodes* Perkins, 1905. Hawaiian Sugar Planters' Assn. Exp. Sta. Bull. 1: 103.

*Pentoxocera phaeodes* Pierce, 1908. Proc. Ent. Soc. Wash. 9: 81.

*Pentozocera phaeodes* Pierce, 1918. Proc. U. S. Nat. Mus. 54: 495.

Diagrammatic sketches of the female only of this and the following species were given by Perkins. The holotypes of both species in the host specimens are in the U. S. National Museum.

Locality, Australia (Queensland); host, *Hecalus immaculatus* Kirkaldy.

***Halictophagus stenodes* Perkins**

*Halictophagus stenodes* Perkins, 1905. Hawaiian Sugar Planters' Assn. Exp. Sta. Bull. 1: 104.

*Pentoxocera stenodes* Pierce, 1908. Proc. Ent. Soc. Wash. 9: 81.

*Pentoxocera stenodes* Pierce, 1918. Proc. U. S. Nat. Mus. 54: 475.

Locality, Australia (Queensland); host, *Paradorydium menalus* Kirkaldy.

***Halictophagus schwarzii* Perkins**

Figure 36

*Halictophagus ? schwarzii* Perkins, 1905. Hawaiian Sugar Planters' Assn. Exp. Sta. Bul. 1: 104.

*Pentacladocera schwarzi* Pierce, 1908. Proc. Ent. Soc. Wash. 9: 80.

Only the male of this species is described and figured by Perkins. The antennae are compact but less so than in *australensis*. The terminal palpal segment is also much longer and more slender than in the latter species. The figure of the aedeagus is from the holotype in the U. S. National Museum.

Locality, Australia (New South Wales); host, *Agallia* species.

***Halictophagus* (?) *tryoni* (Perkins)**

*Megalechthrus tryoni* Perkins, 1905. Hawaiian Sugar Planters' Assn. Exp. Sta. Bul. 1: 106.

Until the male of this species is located it is not certain whether it belongs to *Halictophagus* or *Stenocranophilus*. If it should turn out to be the latter, the name *Megalechthrus* would have priority. Two paratype females are in the U. S. National Museum.

Locality, Australia (Queensland); host, *Platybrachys* species.

***Halictophagus paradeniya* (Pierce)**

*Pentozoe paradeniya* Pierce, 1911. Proc. U. S. Nat. Mus. 40: 505.

Both sexes were described by Pierce. Only the male holotype at the U. S. National Museum has been seen by the writer. The antennae are of the compact type, and the terminal palpal segment is long and tapering. A dorsal view of the male is figured by Pierce (Proc. U. S. Nat. Mus. 54, plate 75).

Locality, Ceylon (Paradeniya); host, *Thompsoniella arcuata* Mots.

***Halictophagus jacobsoni* Meijeire**

*Halictophagus jacobsoni* Meijeire, 1908. Tijd. Ent. 51: 186.

*Neocholax jacobsoni* Pierce, 1909. Bull. U. S. Nat. Mus. 66: 161.

From the figures given by Meijeire, the male antennae are of the compact type but with the third and fourth segments longer than in *paradeniya*. The aedeagus is angularly hooked at the apex, the terminal palpal segment is long and tapering, and the female cephalothorax is nearly round in outline.

Locality, Java; host, *Ossoides lineatus* Bierman.

***Halictophagus javanensis* (Pierce)**

*Cyrtacaraxenos javanensis* Pierce, 1918. Proc. U. S. Nat. Mus. 54: 475.

Figures of the unique holotype male in the U. S. National Museum are given by Pierce. The antennae are greatly compressed at the bases of the segments. The terminal palpal segment is very small; the eyes have unusually large facets; and the aedeagus is slender and sharply barbed at the apex.

Locality, Java (Buitenzorg), at light.

***Halictophagus* (?) *insidiator* (Westwood)**

*Colacina insidiator* Westwood, 1877. Trans. Ent. Soc. Lond., p. 185.

The original description was based by Westwood on characters of the male cephalotheca. Until more material is found, the systematic position of the species is questionable.

Locality, Borneo (Sarawak); host, *Epora subtilis* Walker.

***Halictophagus fulmeki* (Hofeneder)**

*Oedicystis fulmeki* Hofeneder, 1927. Treubia 9: 377.

The single male specimen described and figured by Hofeneder is remarkably similar to, if not the same as, *membraciphaga*. The close relationship is particularly indicated by the aedeagus, which appears to match that of *membraciphaga* exactly. The antennae are compact and the terminal palpal segment is small.

Locality, Sumatra, at light.

***Halictophagus membraciphaga* (Subramaniam)**

Figures 11, 30, 41

*Indoxenos membraciphaga* Subramaniam, 1927. Trans. Ent. Soc. Lond. 75: 132.

The figures were drawn from a long series of topotype specimens sent to the author by T. V. Subramaniam. The antennae are of a moderately compressed type. The female cephalothorax projects onto the abdomen in a long triangle and the female mandible has two distinct teeth.

Locality, India (Mysore State); host, *Otinotus pallescens* Distant.

***Halictophagus compactus* (Pierce)**

*Pyrilloxenos compactus* Pierce, 1914. Proc. Ent. Soc. Wash. 16: 129.

The specific name is derived from the compact antennae. Both sexes are described and the characters of the male are figured by Pierce. The aedeagus is apically hooked and basally inflated. The terminal palpal segment is long and tapering as in *schwarzii*, *jacobsoni* and *paradeniya*. The writer examined three female cotypes at the U. S. National Museum. The cephalothorax is short and apically truncate. The mandibles are set just in front of the brood canal margin and at such an angle that they point almost directly toward each other.

The distribution and life cycle of this species have been recently discussed by K. A. Rahman (1941. Ind. Jour. Agr. Sci. 11: 119-128).



He states that the parasite is often abundant in the sugarcane areas of Punjab and that it has five generations a year.

Locality, India (Bihar); hosts, *Pyrilla aberrans* Kirby and *P. perpusilla* Walker.

#### ***Halictophagus indicus* new species**

*Pyrilloxenos compactus* Subramaniam, 1922. Bull. Ent. Res. 12: 465.

T. V. Subramaniam (above citation) described and figured a halictophagid parasitizing mango jassids in India. He tentatively called it *Pyrilloxenos compactus* Pierce, but indicated that it was possibly different from that species. An examination of a series of specimens sent the writer by Subramaniam proves it to be a new species. *H. indicus* is the first known species of the genus to have four genital tubes in the female. The female mandibles are strongly bidentate with the teeth often well separated as in *gressitti* (fig. 20). It differs from the latter in the character of the basal collar and in the structure of the brood canal opening. It can be separated from *membraciphaga* by the more arcuate brood canal opening and the lateral collar thickenings of the latter. The other Indian species, *compactus*, has a shorter female cephalothorax which has the mandibles pointing toward each other and only one-toothed.

*Male*.—(Dorsal view figured by Subramaniam, 1922. Bull. Ent. Res. 12, plate 15, fig. 1). Antenna compact, segments 3 and 4 slightly longer basally than those following; terminal palpal segment long and cylindrical; eyes with very large and relatively few facets. (Description drawn from immature specimens.)

*Male Cephalotheca*.—Mandible squarish, with two prominent teeth separated by a deep cleft; upper margin of mouth area with a distinct median lip-like projection; mouth area slightly higher than breadth of lower margin which subtends a semicircular pigmented area. Breadth of cephalotheca 0.497 mm., height 0.336 mm.

*Female*.—Cephalothorax deep amber, darker on thorax; basal collar dark brown. Head with a moderate, broad apical lobe; inner apex of mandible with two large teeth separated by a deep cleft; brood passage opening almost straight in the middle, sloping at a 45-degree angle laterally where it is connected with lateral margins of cephalothorax by thickenings just above spiracles; cephalothorax widest opposite brood passage opening; basal collar somewhat shorter than cephalothorax, constricted subapically, bluntly pointed (shape of collar similar to that shown in figure 3). Length of cephalothorax 0.266 mm., length to brood passage opening 0.119 mm., breadth at spiracles 0.238 mm., breadth at base 0.196 mm.

Holotype female, and 9 female paratypes, Mysore State, India (T. V. Subramaniam), on *Idiocerus niveosparvus* Leth. (It is also reported by Subramaniam on *Idiocerus atkinsoni* Leth. and *I. clypealis* Leth. from Mango in Mysore State). Paratypes in collections of California Academy of Sciences and the writer.

***Halictophagus gressitti* new species**

Figures 14, 20

The "squamish" female cephalothorax and the two toothed mandibles easily distinguish this species from all others thus far described in the genus.

*Female*.—Cephalothorax and a short strip on basal collar deep amber, remainder of basal collar very pale amber. Head not projecting in front of mouth, mandible with two well separated strong teeth and an undulate outer margin; brood passage opening not connected with lateral edge of cephalothorax, and with a prominent lip-like margin; base of cephalothorax broad; basal collar roughly square, slightly longer than cephalothorax. Length of cephalothorax 0.490 mm., length from apex to brood canal opening 0.322 mm., breadth at spiracles 0.539 mm., breadth at base 0.434 mm.

*Male Cephalotheca*.—Mandible with two long teeth opposed by a high narrow hump and followed by a second hump near outer base; upper mouth margin without a distinct lip, not surpassing mandibles laterally; mouth area about one and two-fifths as high as width of lower margin. Breadth of cephalotheca 0.98 mm., height 0.56 mm.

Holotype female, 1 female paratype, and male cephalotheca, Liamui, Hainan Island, China, Aug. 2, 1935 (L. Gressitt); 1 female paratype, and male cephalotheca, Nodda, Hainan Island, China, June 28, 1935 (L. Gressitt); on *Tituria chinensis* Distant (E. P. Van Duzee det.). Paratypes in collections of California Academy of Sciences and the writer.

***Halictophagus chinensis* new species**

Figures 13, 43

The peculiar structure of the brood canal opening of the female and the long curved male aedeagus are distinctive. Also, the only two other species thus far described from the Far East, *gressitti* and *orientalis*, both have strongly bidentate female mandibles.

*Male*.<sup>5</sup>—Antenna of moderately compact type, segments 3 and 4 longer basally than segments 5-7, prolongation of segment 5 shorter than that of either 4 or 6, first two segments without large sensoria; terminal palpal segment long and slender, without large sensoria; mandible with parallel sides except at apex; legs long and very slender, middle coxa longer than middle femur, first tarsal segment broadly oval; aedeagus as in figure 43.

*Male Cephalotheca*.—Antennal ring adjacent to mandible; upper mouth margin thick lip-like, reaching mandibles laterally; mandible with weak apical tooth; mouth area about one and a third times as high as breadth of lower mouth margin. Breadth of cephalotheca 0.854 mm., height 0.7 mm.

*Female*.—Cephalothorax amber-colored, basal collar very pale amber with a darker ring (fig. 13); mandible with a single tooth opposed by a prominent hump; brood passage opening narrow and

\*The description of the male is drawn from a fragmentary specimen partially destroyed by fungus, extracted from its puparium.

connected with thickenings to inner base of mandibles rather than with lateral edges of cephalothorax, opening with a distinct lip-like margin; basal collar broadly cape-like, as long as cephalothorax; abdomen with two genital openings. Length of cephalothorax 0.672 mm., length to brood canal opening 0.378 mm., breadth at spiracles 0.742 mm., breadth at base 0.588 mm.

*First Larva*.—Length of body excluding stylets 0.203 mm. Stylets about half as long as rest of body.

Holotype female, allotype male, and 1 female paratype, Tai Au Hong, S. Kiangsi Province, China, July 7, 1936 (L. Gressitt); 3 female paratypes, Yim Na Sen, E. Kwantung Province, June 13, 1936 (L. Gressitt); on *Cicadella ferruginea* Fabr. Paratypes in collections of California Academy of Sciences and the writer.

### ***Halictophagus piperi* new species**

Figs. 12, 29, 40

The distinctive structure of the basal collar in the female and the aedeagus in the male separate this species. It is the first leafhopper parasite to be described from the Philippines.

*Male*.—Antenna compact, segments 3–7 nearly equal in basal length and with long flabellae, first two segments with a few small scattered sensoria; terminal palpal segment a little longer than basal segment, tapering apically, without large sensoria; mandible triangular, about as long as basal palpal segment; eye with not more than twelve facets visible in dorsal aspect and about seven visible in ventral aspect; prescutum of mesothorax unusually large and shield-like, twice as long as pronotum; metanotum as in figure 29; front leg relatively short and stout, tibia twice as long as thick at apex, first tarsal segment broadly oval; middle and hind legs long and slender, middle coxa longer than middle femur; abdominal sternites with two rows of pigmented spots, the last five pairs fused in the middle; aedeagus as in figure 40. Body about 4 mm. long, length of antenna 0.73 mm., length of metanotum 1.44 mm., breadth of head 0.87 mm.

*Male Cephalotheca*.—Antennal ring separated by its radius from mandible; upper mouth margin with a moderate median thickening; mouth area about as high as breadth of lower margin; mandible with two weak apical teeth followed by a fairly sharp angle at outer summit. Breadth of cephalotheca 0.952 mm., height 0.574 mm.

*Female*.—Cephalothorax light brown, darker at sides and base; anterior half of basal collar, except for a dark ring, slightly paler than cephalothorax, posterior half very pale (fig. 12). Mandible with two large apical teeth (inner tooth hidden behind outer in some paratypes) opposed by a moderate hump; brood passage opening broad, connected with lateral edges of cephalothorax by thickenings, opening bounded by a simple thickening, not lip-like; basal collar cape-like with a distinctive necklace-like dark median band which is pointed posteriorly and undulate laterally. Length of cephalothorax 0.581 mm., length to brood canal opening 0.182 mm., breadth at spiracles 0.630 mm., breadth at base 0.511 mm.

*First Larva*.—Length of body excluding stylets 0.238 mm., stylets about two-thirds as long as rest of body.

Holotype male and 1 female paratype, Lamao, Luzon, Philippine Islands, March 6, 1911 (C. V. Piper); female allotype and 2 female paratypes, Rizal, Luzon, Philippine Islands, March, 1930 (A. Duyag); on *Cicadella longa* Wall (Merino det.). Paratypes in collections of California Academy of Sciences and the author.

***Halictophagus orientalis* (Esaki and Hashimoto)**

*Tettigoxenos orientalis* Esaki and Hashimoto, 1931. Pub. Ent. Lab. Kyushu Imp. Univ. 2.

The species is figured in the "Iconographia Insectorum Japonicorum," first edition, 1932. Apparently the male has compact type antennae and a metathorax similar to that figured for *bidentatus* (fig. 23) but with the scutellum proportionately somewhat longer. The female mandibles are figured as strongly bidentate.

Locality, Japan; host, a species of rice leafhopper.

***Halictophagus* (?) *schwarzi* (Pierce)**

*Pentoxocera schwarzi* Pierce, 1909. Bull. U. S. Nat. Mus. 66: 159.

*Pentoxocera schwarzi* Pierce, 1918. Proc. U. S. Nat. Mus. 54: 475.

This species was based on a single male cephalotheca. Until the mature forms are known the relationships are in doubt. If the species should prove to be a true *Halictophagus* the specific name would have to be changed (see *H. schwarzi* Perkins, 1905; p. 354).

Locality, Guatemala (Cacao); host, *Diedrocephala sanguinolenta* Coquibar.

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SHELTER TREES IN WAR AND PEACE, by EPHRAIM PORTER FELT. Pages 1-320, 6 x 8½ inches, 53 illustrations. Published by ORANGE JUDD PUBLISHING COMPANY, INC., New York. 1943. Price, \$2.50.

In these days of the increasing use of aerial attack in warfare, people are becoming more and more aware of the value of trees as a means of concealment. This book deals primarily with the problem of utilizing trees for their protective concealment value, and the importance of a wise tree policy for immediate as well as future needs. Many trees have been destroyed or injured as a result of the hasty establishment of military and industrial projects; these trees may be saved by early treatment more easily than they can be replaced.

The introductory chapters of the book deal with the general relation of trees to human welfare, and the problem of shelter. The main body of the book deals with the structure and growth of trees, the prevention or correction of tree troubles, the problem of selecting shelter trees, the various types of shelter trees, and shelter tree policies.

The book is clearly written and well illustrated. It is an important and timely book in that it presents a situation that has a direct bearing on our war effort. It will be of interest to entomologists because it points out a way in which they can further the war effort—by helping to conserve trees for their shelter value.

—D. J. B.

# THE PRIMARY LARVA AND SYSTEMATIC POSITION OF THE MELOID GENUS POREOSPASTA

(Coleoptera)

J. W. MacSWAIN,<sup>1</sup>

University of California

Leach (1815) was the first to divide the family Meloidae of present day authors into groups. Two of the three major categories which he established were the Meloinae (Meloidae) and the Lyttinae (Cantharidae). Most authors have recognized these two groups, although various names and levels of classification have been applied to them. LeConte and Horn (1883) in their classification of the Coleoptera placed the genus *Poreospasta* in the Meloinae (Meloini). Wellman (1910) accepted the assignment of *Poreospasta* to this group, and placed the genus in one of four subgroups, the Apterospastides. Subsequent authors followed LeConte and Horn, and Wellman, in this respect until Van Dyke (1928) showed that the genus *Poreospasta* was closely related to *Lytta* on the basis of adult characters. He assigned the genus a position intermediate between *Lytta* and *Meloe* and because of this, suppressed the Lyttinae (Lyttini) within the Meloinae (Meloini). Böving and Craighead (1931), using larval characters, have shown that the Lyttinae and Meloinae are amply distinct and of more or less equal value with the subfamilies Zonitinae (Nemognathinae) and Horiinae. The primary larva of *Poreospasta* confirms the conclusion expressed by Van Dyke as to the close relationship of *Lytta* and *Poreospasta*, but it shows no similarity to *Meloe* nor does it exhibit any intermediate characters that invalidate the separation of the Meloinae and Lyttinae as two of the primary divisions of the family Meloidae.

The genus *Poreospasta* is represented by two species, *P. polita* Horn and *P. sublaevis* (Horn), both of which are restricted to California, where they are found in the dryer parts of the San Joaquin Valley, the hills which bound it on the west, and the Mojave desert in the south. Only primary larvae of *polita* were obtained for this study and the description below was based on that species. *Meloe strigulosus* Mann. was selected as representative of the genus *Meloe* although fifteen other domestic and European species were available for comparative study, and *Lytta magister* Lec. was utilized because of the similarity between the larva of that species and *Lytta vesicatoria* L.

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<sup>1</sup>The author is indebted to Dr. E. G. Linsley for many helpful suggestions and assistance in the course of this study.

DESCRIPTION OF FIRST INSTAR LARVA OF  
POREOSPASTA

Body form elongate, slender, subparallel-sided. Length 3.1 mm. to 3.5 mm., greatest abdominal width .5 mm. Color light brown to sepia brown, membranous areas pale yellowish brown to white. Setae few, forming a definite pattern on head, thorax, and abdomen. Ninth abdominal segment with two pairs of macrochaetae, the median pair three and one-half times as long as the outer pair.

Head large, subquadrate, as broad as mesothorax, broadly joined to prothorax. Labrum broad, transverse, with one third total head width, one fourth as long as broad, exerted, covering most of mandibles when closed, anterior margin with a double row of setae; posteriorly separated from clypeus by a well defined clypeo-labral suture. Clypeus complete, narrow, arcuate, laterally bounded by anterior median margins of antennal foramina. Fronto-clypeal suture weakly defined, separating clypeus and frons, marked by a single row of setae on posterior margin of clypeus. Frons well developed, defined anteriorly by the fronto-clypeal suture, laterally by the antennal bases and posteriorly by the lateral arms of the (epicranial) suture. Epicranial suture well defined, attaining posterior margin of head, anterior arms attaining antennal foramina. Epicranial halves with a definite pattern of dorsal setae and three pairs of ventral lateral setae directly below ocelli. Ocelli a single pair, equal in diameter to sensory appendices of second antennal segment in anterior one third of epicranial halves about two thirds of the distance from the epicranial suture to lateral margin of head. Antennal foramen large, anteriorly contiguous with the mandibular foramen. Antennae three-segmented, exclusive of terminal macrochaeta about twice as long as broad, first two segments subequal in width, broader than long, the second segment with a sensory appendix on the ventral lateral apex, the third segment laterally articulated with the second, about two and one-half times as long as broad, terminal macrochaeta over three times as long as segment, several shorter setae on second and third segments and (sensory) pits on segments one and two. Mandibles subangularly arcuate, as long as from posterior margin of head to posterior margin of antennal foramen, basically enlarged, apical half sharply attenuate, condyle on outer third of posterior margin. Maxillae well developed, weakly sclerotized, equal in length to mandible; cardo broad, short, about one-third length of stipes; cardo and stipes forming a broad flat plate about twice as long as broad, slightly attenuate posteriorly; stipes with two long median setae, numerous setae on anterior inner margin; maxillary palpi three-segmented, equal in length to width of labrum, surpassing anterior margin of labrum, first two segments each broader than long, subequal; third segment equal in length to first two segments, with numerous small setae on apex. Labium well defined, weakly sclerotized, about as long as broad, anteriorly attaining an imaginary median line transverse across labrum; labial palpi two-segmented, twice as long as mentum, second segment of palpi twice as long as first and one half as broad as maxillary palpi; mentum

subquadrate, with two long median setae and two short setae on posterior margin; submentum broad, flat, twice as long as mentum, posteriorly attenuate. Gula narrow, parallel-sided, about four times as long as broad.

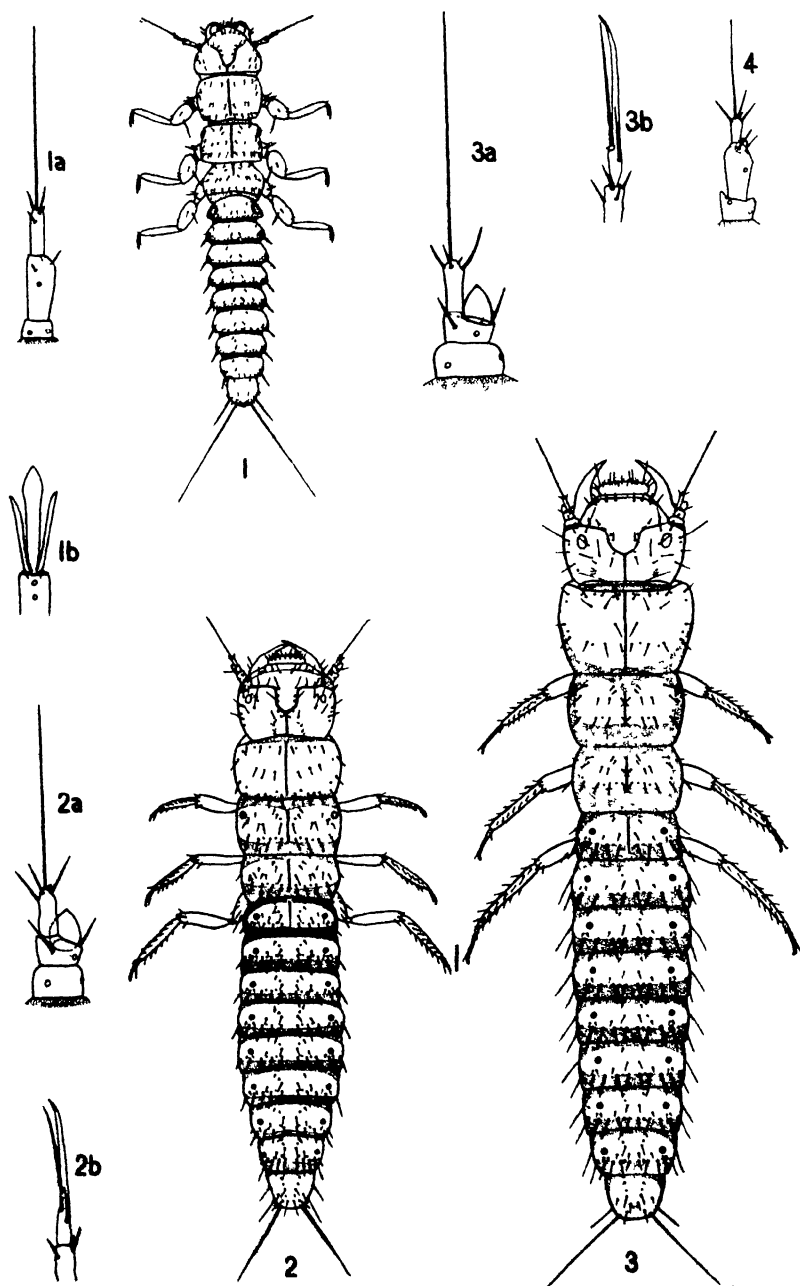
**Thorax** one half as long as abdomen, segments with a definite pattern of long tergal setae, a few small setae on dorsal and lateral membranous areas and sternites. Prothorax slightly wider and shorter than head, postero-lateral angles broadly rounded; pronotal shield rectangular, covering almost entire tergum; medio-dorsal suture fully developed, extending the entire length of the tergal plate; sternal elements not as strongly chitinized as notum. Meso- and metathorax decreasing in size, smaller than prothorax and with smaller tergal plates. Mesothoracic spiracle moderately large, on antero-lateral margin of tergal plate. Legs elongate, slender, increasing in length; coxae robust, about two thirds as long as prothoracic tergal plate, twice as long as broad, several long setae on distal one third of segment; articulated to a dorsal pleural plate, plates triangular, decreasing in size on meso- and metathorax; trochanters small, weakly sclerotized, about one fifth as long as coxae, as long as broad; femora slightly longer than coxae, one-fourth as broad as long, base of segment moderately broad, narrowed to apex, surface with three rows of short setae; tarsi one third as long as tibiae, tapering, apex curved, major seta nearly attaining apex, minor seta one third as long as major seta.

**Abdomen** with first tergite completely divided by a median suture continuous with those of the thorax; spiracle of first tergite slightly smaller than mesothoracic spiracle, spiracles on first to eighth tergites laterally placed, medially about three fourths of the distance from the median line to lateral margin of segment, spiracle of eighth tergite one half the diameter of mesothoracic spiracle; segments increasing in width from first to fifth, decreasing from fifth to ninth, first tergite about three times as broad as long, fifth tergite about four times as broad as long, about one and one fourth times as broad as first tergite, ninth segment subquadrate, slightly longer than broad, a single row of setae along posterior margins of the abdominal tergites, about as long as the tergites, small regularly placed setae and (sensory) pits in median portion of plates. No visible sternites.

On the basis of the primary larva, *Poreospasta* may be placed in the subfamily *Lyttinae* by the following combination of characters: head subquadrate, labrum, clypeus and frons not fused, antennae with a

#### EXPLANATION OF PLATE

Fig. 1. *Meloe strigosus* Mann., first instar larva, dorsal view,  $\times 22$ . 1a. *M. strigosus* Mann., antenna, dorsal view,  $\times 125$ . 1b. *M. strigosus* Mann., tarsus, dorsal view,  $\times 125$ . 2. *Poreospasta polita* Horn, first instar larva, dorsal view,  $\times 22$ . 2a. *P. polita*, antenna, dorsal view,  $\times 125$ . 2b. *P. polita* Horn, tarsus, lateral view,  $\times 125$ . 3. *Lytta magister* Lec., first instar larva, dorsal view,  $\times 22$ . 3a. *L. magister* Lec., antenna, dorsal view,  $\times 125$ . 3b. *L. magister* Lec., tarsus, lateral view,  $\times 125$ . 4. *Epicauta puncticollis* (Mann.), antenna, dorsal view,  $\times 125$ .





large sensory appendix on the lateral apex of the second segment, ocelli reduced to a single pair, abdominal spiracles uniform in size and position, and ventral integument thin.

Unfortunately the inadequate number of primary larvae of *Lytta* available for study make it impractical to distinguish the genera *Lytta* and *Poreospasta* generically. *Poreospasta polita* may be separated from *Lytta magister* on the basis of the following characters: sensory appendix of the second antennal segment equal in size to the ocellus rather than subequal, third segment of the maxillary palpus equal in length to the first two segments rather than shorter than these segments, antennal foramen larger than first antennal segment rather than smaller, and (lateral arms of) epicranial suture attaining the antennal foramen rather than falling short of the antennal foramen. Both *Poreospasta* and *Lytta* may be readily separated from the other members of the subfamily which have been described by the short second antennal segment with the large sensory appendix on the lateral apex (compare with *Epicauta*, (fig. 4), and *Macrobasis*).

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A MANUAL OF EXPERIMENTAL EMBRYOLOGY, by VIKTOR HAMBURGER. Pages xvii and 213, 142 figs. 1942. Cloth, octavo. Published by THE UNIVERSITY OF CHICAGO PRESS. Price, \$2.50.

Among recent purchases of books for our own library is one we wish to call to the attention of those interested in insect embryology. It gives detailed instructions for experimental work on vertebrate eggs. While the usual insect egg is so condensed and has such a hard yolk that experimental work becomes very difficult we ever hope that more attempts will be made to do such work. The clear outline given by Hamburger may suggest parallel operations that could be used on insect eggs.

The subjects treated in detail are: Part I. Equipment; II. Experiments on Amphibian Embryos; III. Experiments on the Chicken Embryo; IV. Regeneration; V. The Gradient Theory. And: Appendix: Plan for a One Semester Course. Index.—C. H. K.

## STUDIES IN NEOTROPICAL STRATIOMYIDAE

### (Diptera)

#### V. THE CLASSIFICATION OF THE RHAPHIOCERINAE

MAURICE T. JAMES,

Colorado State College,

Ft. Collins, Colorado

The position of the several genera of Stratiomyidae treated in this paper has been a subject of considerable disagreement. Macquart (1834, 1838) laid the foundation for the classification of this subfamily when he described *Hoplistes*, *Dicranophora*, *Rhaphiocera* and *Basentidema*; and, although these genera did not come together in his outline classification, they were numbered consecutively (16 to 19 respectively) and followed each other in the text. Loew (1855) proposed the name *Analcocerus* and considered this genus, together with the four of Macquart, in his discussion of the "Sargus-Arten." Schiner (1868) proposed the generic name *Histiodyroma* for *Sargus inermis* Wied., and the subfamily name *Rhaphiocerinae* in essentially the same sense in which it is used in the present paper.

Subsequent attempts to determine relationships in this group have been less successful, mainly because of the emphasis placed upon antennal structure in the systems of classification. At first sight, the aristate type of antenna found in *Rhaphiocera* and the elongated, eight-segmented type of *Analcocerus* appear quite different. If this differentiation is an ancient one, the similarity in appearance in other respects may be considered the result of divergence. To me, this viewpoint is highly objectionable, since, in the first place, there are several cases of exactly parallel "divergence" in the Stratiomyidae, and, in the second, there are cases of gradual transition from one type to another. This subject will be discussed more completely in another paper.

Among more recent dispositions of these genera and attempts to define the genera themselves we might mention those of Brauer (1882), Williston (1888 and 1900), Kertész (1908), Enderlein (1914) and Lindner (1931). Brauer, though placing *Analcocerus*, *Rhaphiocera*, etc. in the "Sargidae," was impressed by the difference in antennal structure to such an extent as to associate *Analcocerus* with *Campeprosopa*, *Eudmeta*, and *Acrochaeta* in a separate division. Kertész has transferred the above group to the Hermetiinae, whereas Williston states that *Analcocerus* (also *Campeprosopa*, which, however, he misunderstood) "clearly belong to the Sarginae." Enderlein has proposed for *Analcocerus* a new subfamily name, *Analcocerinae*.

The antennal evolution of this group appears to be approximately as follows. In all members, the antennae have been reduced to eight segments, segment eight, according to Enderlein's interpretation, representing numbers eight to ten of the primitive Stratiomyid antenna.

Then segments three to five (the first three of the flagellum) become shortened and compact, (as in *Euparyphus*, *Adoxomyia*, and other genera showing a tendency toward arista formation); the other segments, especially the last one, become more elongated. This transition is made from *Neanalcoerus* to *Analcocer*. The basal three segments of the flagellum having already become short and compact, the apical three now become lengthened and thinned out into an arista which is at first terminal (e. g. in *Rhaphiocera*), but later migrates dorsad of the fifth antennal segment (e. g. in *Basenidema*). Thus the three divisions, as recognized by Enderlein (no arista, dorsal arista, terminal arista) can be maintained, if their phylogenetic relationship is recognized.

The subfamily as here outlined will be more difficult to define than that of the Brauer-Kertész-Enderlein classification; but I believe it is more nearly natural. All members are more or less elongated, slender flies, with inconspicuous pile, and usually black with conspicuously yellow or green markings which conform to surprisingly similar patterns. The antennae are eight-segmented, though the last three may form an arista and the three preceding ones are usually compact and closely united, though with distinct annulations; the antennae are longer than the head. The eyes are broadly separated in both sexes, and in all known species are bare. The mouth parts are well developed. The thorax is usually narrow in front and widens to a maximum at the wing bases. The scutellum is two-spined, although often the spines are reduced or lost. The wings tend toward unusual forms and venation, such as a thickening or even a great expansion of the costa; a truncation of the upper apical angle, the assumption of a triangular form through the weakening of the anal angle, the weakening of the base of vein  $R_4$  and the fracturing of  $R_1$  (sometimes also the costa) near the origin of  $R_4$ , etc. Wing veins are strong; cross veins r-m and m-cu are present and usually long; the media is three branched, and the branches are long and strong; there are five posterior and usually two submarginal cells; vein  $R_4$  is frequently bent downward at its point of separation from  $R_4$ . The abdomen is slender and as long or longer, but usually no wider, than the thorax. The legs are relatively long, sometimes with modifications.

So far as known, the subfamily is strictly Neotropical. The Palaearctic genus *Rhaphiocerina* certainly does not belong here, but probably instead to the Stratiomyinae, along with *Nothomyia*.

#### KEY TO THE GENERA OF RHAPHIOCERINAE

1. Antennae elongated, the flagellum eight-segmented, without an arista. . . . . 2  
    Antennae shortened, the flagellum with a well-defined arista, the annulated part usually not much longer than the second segment. . . . . 3
2. Last segment of flagellum two or three times as long as preceding one; basal three segments of flagellum very short; costa may be thickened at stigma, but not beyond; stigma relatively long.  $R_{4+5}$  arising at a considerable distance beyond cross vein r-m (p. 367). . . . . *Analcocer*  
    Last segment of flagellum barely longer than preceding one; basal segments of flagellum not greatly shortened; costa thickened beyond stigma; stigma short, origin of  $R_{4+5}$  interstitial with cross vein r-m, or nearly so (p. 370). . . . . *Neanalcoerus*
3. First antennal segment twice length of second; vein  $R_{4+5}$  evanescent on apical half (p. 371). . . . . *Lycerus*  
    First antennal segment subequal in length to second; vein  $R_{4+5}$  complete. . . . . 4

4. Scutellum with a strongly developed median process, forked at end, which in one species reaches to apex of abdomen; or, if this process is not evident, the scutellar spines (really the above mentioned forks) are robust, longer than the scutellum, and curved inward at apex; middle femora, at least in male, with prominent irregular spines or dentitions below; metapleura each usually with a mammiform tubercle; vein  $R_4$  absent (p. 371), **Dicranophora**  
 Scutellum without a forked median process, only with the usual spines or unspined; middle femora and metapleura unmodified; vein  $R_4$  usually present.....5
5. Costa more or less thickened and expanded beyond stigma, at least in males conspicuously so; discal cell roughly diamond-shaped, though basal angle is definitely more obtuse than apical one; third and fourth posterior cells narrow, their combined width about equal to that of the first or second (p. 373).....**Histiodroma**  
 Costa not conspicuously thickened; discal cell rectangular, pentagonal or hexagonal; third and fourth posterior cells each equal or nearly so, in width to first or second.....6
6. Vein  $R_1$  beyond point of separation from  $R_2$  greatly weakened; base of  $R_2$  strong; wings truncated at apex; discal cell quadrilateral, with lower apical corner rounded (p. 375).....**Cyclophleps**  
 Vein  $R_1$  not weakened at apex; vein  $R_2$  often evanescent at base; wings not truncated; discal cell pentagonal or hexagonal, the corners angular.....7
7. Arista slightly dorsal in position; abdomen parallel-sided, or almost so (p. 376).....**Basentidema**  
 Arista apical; abdomen broadening toward apex.....8
8. Costal margin of first submarginal cell twice that of second; discal cell half again as long as broad, and lying chiefly beyond cross vein r-m (p. 377), **Hoplistes**  
 Costal margins of first and second submarginal cells subequal; discal cell about as long as broad, or its elongation attained by extension basad of r-m (p. 378).....**Rhaphiocera**

### **Analcocerus** Loew

*Analcocerus* Loew, 1855, Verh. zool.-bot. Ver. Wien, 5: 140, 147; Enderlein, 1914, Zool. Anz., 43: 597.

*Campeprosopa* Williston, 1900, Biol. Centr. Amer. Dipt., I, p. 239 (not Macquart, 1850).

To the characters given in the key the following may be added: the first and second antennal segments are subequal, but each elongated, being three to four times as long as wide; the sixth to eighth segments are concave posteriorly; the scutellum is two-spined;  $R_2$  is evanescent at its base, and  $R_1$  weakened at the origin of  $R_2$ . The thorax and legs are without special modifications, except sometimes a thickening of the hind basitarsi.

Genotype, *A. atriceps* Lw., by original designation.

### KEY TO THE SPECIES OF ANALCOCERUS

1. Abdomen with narrowly interrupted pale bands on posterior margins of segments one to five.....**longicornis**  
 Abdomen with a transverse band; not interrupted and not attaining lateral margins, on segment one, otherwise with only lateral margins pale, this color sometimes extending inward at incisures.....2
2. Middle and hind tibiae brown.....**atriceps**  
 Middle and hind tibiae yellow.....3
3. Front with a prominent yellow spot below ocelli; postocular orbits mainly yellow; scutellar spines no longer than scutellum, blackish, slightly divergent.....**orbitalis**  
 Front black immediately below ocelli; postocular orbits mainly black; scutellar spines longer than scutellum, yellow, strongly divergent.....**taurus**

***Analocercus longicornis* (Williston)**

*Campeprosopa longicornis* Williston, 1900, *Biologia Centr. Amer. Dipt.*, I, p. 239.

Described from a female from Omilteme, Guerrero, Mexico. I have seen no specimens. It is apparently an *Analocercus*, however, in spite of Williston's statement that the antennae are seven-segmented. The abdominal markings will readily distinguish this species from the South American ones.

***Analocercus atriceps* Loew**

*Analocercus atriceps* Loew, 1855, *Verh. zool.-bot. Ver. Wien*, 5: 140; Enderlein, 1914, *Zool. Anz.*, 43: 597.

Of the new species described below, *atriceps* is closer to *taurus* than to *orbitalis*; but the scutellar spines are not especially long and divergent in the male, the tibiae are brown, and the green spots on the postocular orbits are wanting. The wings are clouded as in *taurus*. The thoracic and abdominal patterns in this and the two following species are, in general, similar.

Recorded by Enderlein from Santa Catharina, Brazil, and by Lindner from Itatiaya, Brazil. I have a male and a female specimen from Itatiaya, determined by Lindner.

***Analocercus orbitalis* new species****Figure 2**

*Male*.—Antennae about twice length of head; segments from lateral view of equal width, apical one rounded; ratio of length 11:9:2:2:5:6:15; first and second segments yellow, with short black pile; others black. Head black, prominently marked with yellow as follows: a large spot adjacent to ocellar triangle and occupying most of upper half of front, except along eyes; a spot adjacent to eyes on each side of front above antennae and one similarly placed on face below antennae, the two sometimes connected along ocular orbits; a spot on each side of oral margin; and postocular orbits, the yellow extending onto occiput near vertex; postocular orbits, however, are black above adjacent to eyes and black below adjacent to occiput. Proboscis black. Front at anterior ocellus wide as length of first antennal segment, somewhat wider at antennal bases. Thorax black, except following yellow areas: humeri; postalar calli and small triangle in front of and adjacent to them; two rather arcuate dorsal stripes which attain neither humeri nor postalar calli; scutellum; upper margin of pleura from humeri to wing bases, thence continuing in an oblique band across posterior margin of mesopleura onto sternopleura; and most of metapleura and hypopleura. Scutellar spines as long as scutellum or slightly shorter, brownish to blackish, sharp, slightly divergent. Pile of thorax inconspicuous, appressed, pale. Halteres yellow. Legs yellow, basal three segments of hind tarsi white, last segment of all tarsi brownish yellow. Wings hyaline, veins yellow. Abdomen black, marked with yellow as follows: a transverse band, separated from lateral margins, on first segment; lateral margins of dorsum and venter, narrow on venter and first and fifth seg-

ments dorsally, broader on other dorsal segments, on each of which it broadens toward posterior margin of segment; and sometimes a pair of small dorsal spots on second segment. Genitalia small, yellow. Length, 8 mm.

*Female*.—Differs but slightly from the male. All tarsi are whitish, except apically, and the bases of the tibiae, especially the front and hind ones, are brownish. The markings of the abdomen are greenish, but this probably has no significance.

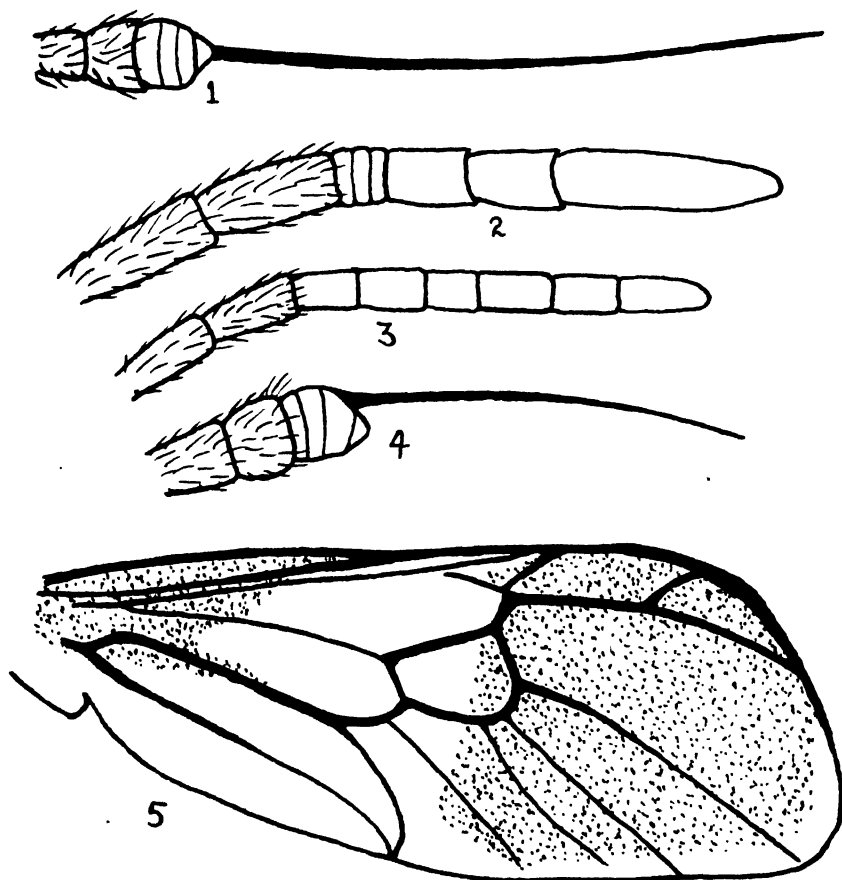


FIGURE 1. *Rhaphiocera armata* (Wied.), antenna. 2. *Analcocerus orbitalis* n. sp., antenna. 3. *Neanalcocerus hortulanus* (Will.), antenna. 4. *Basentidema coerulescens* n. sp., antenna. 5. *Cyclophleps tenebrifera* n. sp., wing.

*Types*.—Holotype male, Nova Teutonia, Brazil, Dec. 20, 1937 (Fritz Plaumann); American Museum of Natural History. Allotype female, same data, but Feb., 1939. Paratype males, same data, but Dec. 14, 1937, and Nov. 17, 1936.

***Analcocerus taurus* new species**

*Male*.—Similar to the above species. Antennal structure practically the same. Head black, with a small green spot bordering each eye above antennae and another in like position below; postocular orbits on each side with a small green spot near upper angle of each eye. Thoracic pattern similar to that of *orbitalis*, but markings greenish; upper pleural margins narrow; hypopleura black, variably marked with yellow; narrow base of scutellum black. Scutellar spines one-third again as long as scutellum, strongly divergent, slender, and sharp, brownish-yellow in contrast to green of scutellum. Legs yellow, tarsi on basal three segments white. Wings with a brownish cloud running lengthwise of the anal and second basal cells, and another at wing apex in first and second posterior cell. Abdomen marked as in *orbitalis* except that first abdominal segment is without a yellow margin and there are no spots in middle of second segment. Length, 8 mm.

*Female*.—Scutellar spines no longer than scutellum, only moderately divergent, and more robust than in male.

*Types*.—Holotype male, S. Sebastião, Brazil, Nov. (C. W. Johnson); Museum of Comparative Zoology, No. 25660. Allotype female, Parque Cajuru, São Paulo, Dec., 1911 (Schrobel); Museu Paulista. Also a male in teneral condition, not a type, Alto da Serra, S. Paulo, Nov. 29, 1908 (Luederwaldt).

***Neanalcocerus* new genus**

*Analcocerus* Williston, 1900, Biol. Centr. Amer. Dipt., I, p. 238; Curran, 1934, North American Diptera, p. 143 and fig. 26; not Loew, 1855.

Distinguished from *Analcocerus* chiefly by the venation and antennal structure. First and second antennal segments long and slender, subequal in length; the other six subequal in length, each a little more than half the length of the first or second, the eighth segment slightly longer than the preceding ones. Costa strongly thickened apically (but not expanded as in *Histiodroma*), and ends near the blunt wing apex; discal cell small; cross-vein r-m very long, almost as long as the smaller diameter of the discal cell, and fully as long as the portion of vein  $M_{1+2}$  from the cross-vein to its furcation.

Genotype, *Neanalcocerus* (*Analcocerus*) *hortulanus* (Williston).

***Neanalcocerus hortulanus* (Williston)****Figure 3**

*Analcocerus hortulanus* Williston, 1900, Biologia Centr. Amer. Dipt., I, p. 238.

Described from two females from Yucatan. A male in my collection, Acapulco, Guerrero, Mexico, June 15, 1936 (A. E. Pritchard), agrees well with Williston's description and illustration, with the following exceptions: the markings on the body are a bright, pastel green; the hind femora have a dark median annulus; and the hind tibiae are in large part brownish. The venation differs slightly from the illustration; vein  $R_4$  bends downward slightly after it separates from  $R_4$ , and  $R_{3+4}$  originates slightly behind, almost interstitial with, r-m.

**Lysozus Enderlein**

*Lysozus* Enderlein, 1914, Zool. Anz., 43: 579.

According to Enderlein's diagnosis of the genus, the first antennal segment is four times as long as wide, the second twice as long as wide, and the arista set dorsally on the short oval flagellum; the scutellum is two-spined; and vein  $R_{2+3}$  vanishes at its apical half.

Genotype, *Lysozus columbianus* Enderlein, by monotypy.

**Lysozus columbianus Enderlein**

*Lysozus columbianus* Enderlein, 1914, Zool. Anz., 43: 579.

This species, the only one known, was described from one specimen from Colombia, and has not been recorded since.

**Dicranophora Macquart**

*Dicranophora* Macquart, 1834, Suites à Buffon, I, p. 255; Macquart, 1838, Dipt. Exot., I, 1, p. 195; Loew, 1855, Verh. zool.-bot. Ver. Wien, 5: 141.

This genus has several interesting peculiarities which are given in the key. To these characters it may be added that the antennae are short, with the arista terminal or slightly dorsal, and the wing is unmodified as to thickenings, truncation, etc., the only outstanding wing character being the lack of vein  $R_4$ , a character which I have not seen elsewhere in this subfamily except as an occasional abnormality in *Rhaphiocera*.

Genotype, *Dicranophora* (*Sargus*) *furcifera* (Wiedemann), by designation of Macquart (1838).

This genus seems to be poorly represented in collections. I have examined the types of *astula*, *affinis*, and *brevifurca*; also a specimen of *furcifera* in the American Museum of Natural History. *D. picta* has been placed in my key on the basis of Macquart's description and figures.

**KEY TO THE SPECIES OF DICRANOPHORA**

1. Scutellar process reduced, hardly evident except for its furcations, which appear as strong bowed spines..... **brevifurca**  
Scutellar process before furcation usually at least as long as rest of scutellum..... 2
2. Scutellar process prolonged to apex of abdomen..... **furcifera**  
Scutellar process not extending beyond second abdominal segment..... 3
3. Abdomen wholly pale; mesonotum with a conspicuous triangular spot on each side in front of suture..... **astuta**  
Abdomen black, with pale markings; mesonotum without lateral presutural triangles..... 4
4. First and second abdominal segments each with a conspicuous yellow spot in the middle..... **affinis**  
First abdominal segment with a narrow yellow posterior margin, second wholly black..... **picta**

***Dicranophora brevifurca* new species**

Readily distinguishable from other described species by the very short scutellar process which, except for its terminal spines, would not be recognizable as such except by comparison with other species. This species, however, is clearly a *Dicranophora*, as evidenced by its other morphological characters.



*Male*.—Head yellow, marked with black as follows: ocellar triangle; a narrow band extending from ocellar triangle to each eye, thence bending backward narrowly along suture between vertex and occipital orbits, and connecting to center of occiput; a large bell-shaped spot on the front; and occiput, except orbits; also an indistinctly defined brownish area above antennae, and a spot of similar color to each side along oral margins. Front at middle one-third width of head, slightly narrower above and broader below. Face white pilose; front and vertex almost bare. Antennae yellow; first and second segments and annulated part of flagellum subequal, arista almost twice length of rest of antennae. Thorax black dorsally, marked with yellow as follows: humeri, supra-alar calli and adjacent areas, a pair of mid-dorsal stripes extending from humeri to a point three-fifths distance from suture to scutellum, and connecting stripes extending from this pair to the dorso-pleural suture and there expanding into larger spots. Scutellum yellow, narrow base and spines black; spines somewhat longer than scutellum, thick, divergent, but at the apex curving inward, blunt apically; what appear to be the spines probably represent the remains of the furcate scutellar process characteristic of this genus, but which in the present species is hardly recognizable as such. Metanotum black in center, its slopes yellow; pleura yellow, with a black spot above each middle coxa, one below each wing base, and one on each mesopleuron; prosternum black in middle, mesosternum with a large black triangle on each side, extending from middle coxa almost to front one; metapleura each with a prominent mammiiform tubercle. Legs yellow; front tibiae and tarsi black, the former somewhat brownish below; hind tibiae narrowly at base and apex, middle knees, and last two or three segments of middle and hind tarsi black. Middle trochanters produced strongly below at point of articulation with coxae; their femora at about middle third below expanded into a stout tubercle with a jagged under surface composed of five or six teeth on the lower surface of the tubercle and four or five more basad to it. Halteres unusually large, yellow, more brownish at base. Wings hyaline; veins yellow. Abdomen yellow; beyond segment one dorsally obscurely brownish in middle, with yellow triangles on posterior margins of segments two to four, largest on two, smallest on four; venter yellow, unicolorous. Genitalia yellow. Length, 7 mm.

*Types*.—Holotype male, Villarica, Paraguay, October (F. Schade); Museum of Comparative Zoology No. 25661. Paratypes, male, same data, and male, Villarica, Paraguay, Dec., 1938 (Schade), C. W. Sabrosky collection.

#### ***Dicranophora furcifera* (Wiedemann)**

*Sargus furcifer* Wiedemann, 1824, Anal. Ent., 31, 40; 1830, Zweifl. Ins., II, p. 38.

*Dicranophora furcifer* Macquart, 1838, Dipt. Exot., I, 1, p. 195.

Type from Brazil. Macquart records this species from Rio de Janeiro.

#### ***Dicranophora astuta* Williston**

*Dicranophora astuta* Williston, 1888, Trans. Amer. Ent. Soc., 15: 250.

Type from Brazil.

**Dicranophora affinis** Williston

*Dicranophora affinis* Williston, 1888, Trans. Amer. Ent. Soc., 15: 251.

Type, ♀, from Rio de Janeiro. A male, Rio de Janeiro, Oct., 1919 (C. H. Curran), in the American Museum of Natural History, conforms with Williston's description.

**Dicranophora picta** Macquart

*Dicranophora picta* Macquart, 1834, Suites à Buffon, I, p. 255; Macquart, 1838, Dipt. Exot. I, 1, p. 196; Williston, 1888, Trans. Amer. Ent. Soc., 15: 250.

Type from Brazil.

**Histiodroma** Schiner

*Histiodroma* Schiner, 1867, Verh. zool.-bot. Ges. Wien, 17: 308; Schiner, 1868, Reise Novara, p. 68; Brauer, 1882, Denkschr. kais. Akad. Wiss. Wien, 44: 70.

Genotype, *Histiodroma* (*Sargus*) *inermis* (Wiedemann).

The three species known to me can be separated by the following key. A fourth species, *H. flaveola* Bigot, has been described from Mexico, but from the description alone it is impossible to determine whether the generic reference of this species is correct.

1. Wings with two conspicuous black bands, one crossing and including the discal cell and the other at the apex. . . . . **fascipennis**  
Wings yellowish, sometimes with a light shadow in the above regions, but never black. . . . . 2
2. Abdomen black; scutellum with spines reduced to tubercles; first antennal segment twice as long as second. . . . . **inermis**  
Abdomen yellow; scutellum with spines strong; first and second antennal segments subequal in length. . . . . **tricolor**

**Histiodroma fascipennis** new species

A black species, with predominantly black legs and with conspicuously cross-banded wings.

*Male*.—Head black; front on its lower third with a pair of rounded or oval spots. Front about one-fifth width of head, parallel-sided; face about same width. Front almost bare; face, proboscis, cheeks, and occiput with whitish pile. Antennae, including arista, bright yellow; first and second segments subequal to each other and to annulated part of flagellum; arista one and two-thirds combined length of rest of antenna. Thorax black, except following areas, which are pale green: scutellum including spines; humeri; a small spot above each wing base; a pair of crescentic or oval spots running lengthwise of the disc, behind the suture; and an oblique band on each pleuron, consisting of the posterior margin of the mesopleuron connected with a squarish marking on the sternopleuron. Pile whitish. Legs black, shading to a variable degree to yellow; but usually the trochanters, the bases of the middle and hind femora and the middle and hind basitarsi, and sometimes also the bases and apices of the front femora, are yellowish. Halteres yellow, with green knobs. Wings subhyaline, with two broad black bands; the first fills the apices of the basal cells, the bases of the first submarginal and of the first three posterior cells, and all of the discal and fourth and fifth posterior cells; the second fills the apex of the wing from slightly before vein R<sub>4</sub>;

there is also a shadow running lengthwise of the second basal and anal cells. Thickening of costal area extending beyond apex of  $R_4$ , but greatly narrowed at apical half of first submarginal cell, which is correspondingly widened. Abdomen black, with white pile; genitalia and apex of fifth segment yellow. Length, 7-8 mm.

*Female*.—Expansion of costal area much less marked; it is narrow at base and disappears near middle of first submarginal cell.

*Types*.—Holotype male, Cotia, São Paulo, Brazil, Dec. 27, 1940 (A. G. Silva); Instituto de Hygiene de São Paulo. Allotype female, Juquia, Faz. Poco Granda, São Paulo, Brazil, June 6-9, 1940 (F. Lane, Trav. Fo., and C. Carvalho); Museu Paulista. Paratypes: 5 males, same data as holotype; 1 male, 1 female, same data as allotype.

The species is subject to some variation. The legs, as already noted, vary in color; the crescentic spots of the thorax may be reduced or absent; the arista may be brown or black. The pale markings of the head and thorax may vary from green to yellow; frequently the spots of the head and sternopleura are yellow, although both may be green.

### *Histiodroma inermis* (Wiedemann)

*Sargus inermis* Wiedemann, 1830, *Aus. Zw. Ins.*, II, 31.

*Histiodroma inermis* Schiner, 1868, *Reise Novara*, p. 68.

Types from Brazil. Recorded from Rio de Janeiro by Williston.

### *Histiodroma tricolor* James

*Histiodroma tricolor* James, 1940, *Arb. morph. taxon. Ent.*, 7: 121.

A handsome species, superficially resembling *Hoplites bispinosus*. The thorax is black, with green markings, the abdomen yellow. The types are males from La Merced, Chancosmayo, Peru; in addition, I have seen 1 ♂, Peru, March 24, 1923 (C. H. Curran).

### *Histiodroma flaveola* Bigot

*Histiodroma flaveola* Bigot, 1879, *Ann. Soc. Ent. France*, (5) 11: 205.

I quote the original description.

"Antennis obscure fulvis, apice et chaeto fuscis; fronte et facie flavis; thorace flavo, vittis duabus longitudinalibus, subcontiguis, utrinque vitta lata abbreviata, interrupta, striga deinde laterali, nigro fusco, pleuris utrinque fusco late unimaculatis; scutello nigro, apice flavo; halteribus testaceis, apice fuscis; abdomine testaceo-flavo, nigro fusco late sex vittato; pedibus testaceis, femoribus apice, subtus, castaneo notatis, tarsis anterioribus apice fuscis; alis apice testaceis, intus et apice obscurioribus.

"Antennes d'un fauve obscur, plus foncées vers l'extrémité, chète noirâtre; face et front jaunes, une macule ocellifère, une demi-bande de chaque côté, partant du vertex et s'arrêtant à mi-distance des antennes aux bords des orbites, noires; thorax jaune, une double bande médiane, longitudinale, une large bande latérale, interrompue à la suture, n'atteignant pas les bords, une ligne joignant l'épaule à la base de l'aile, une large macule en dessous du prothorax, brun foncé; écusson jaune à bas noire; métathorax violet en dessus; balanciers testacés, massue noirâtre en dessus; abdomen d'un jaune testacé,

avec six large bandes, sises à la base des segmentes, atteignant à peine les côtés, d'un brun noirâtre; pieds testacés, cuisses teintées de brun en dessus, vers leur extrémité, surtout aux postérieures, tarses antérieurs largement teintés de brun à l'extrémité, pelotes testacées; ailes d'un testacé pâle un peu plus foncé au bord externe et sur les nervures.

"Mexico. Ma Collection."

### **Cyclophleps new genus**

Related to *Rhaphiocera*, and with the same general body form, but differing markedly in wing venation. First and second segments of antennae subequal to each other and to annulated part of flagellum; arista terminal. Scutellum with two strong spines. Legs without special modifications. Wing broadened at apex, truncated on upper apical angle; anal area weakly developed. Submarginal cells short and broad; discal cell about half again as long as its greatest breadth, roughly a rectangle, with the lower apical corner distinctly rounded. Vein  $R_{1+2}$  arising slightly before r-m.

Genotype, *Cyclophleps tenebrifera* n. sp.

### **Cyclophleps tenebrifera new species**

#### **Figure 5**

*Male*.—Variegated yellow (or green) and black. Head yellow; center of occiput, a band on vertex including ocellar triangle, and another on upper part of front, black; the last mentioned connects along ocular orbits with vertical band, and below its outline is M-shaped. Proboscis, palpi, and antennae yellow; arista black, two and a half times length of basal part of antennae. Vertex about one-fifth width of head; front gradually widening to about two-sevenths head width at base of antennae. Postocular orbits much more strongly developed below than above. Dorsum of thorax much broader at wing bases than at humeri; black with humeri, supraalar calli, a large lateral triangle on each side in front of suture, two narrow stripes running from humeri to suture, two elongated-oval spots behind suture and not quite in line with the longitudinal stripes, and apex and posterior margin of scutellum, pale green or yellow. Post-scutellum and metanotum black. Pleura green or yellow; a diagonal stripe on mesonotum, a spot below each wing base, and one above each middle coxa, black; sterna in large part black. Halteres yellow. Coxae yellow, hind ones black anteriorly; trochanters mainly brown; basal third or more of all femora yellow; knees more or less yellowish; legs otherwise black. Wings hyaline, with marginal and submarginal cells, and entire apex of wing beyond a line running from crossvein r-m to apex of anal cell, black; extreme tip of wing not quite so dark; basal part of cubitus broadly margined with black; posterior margin of wing (posterior half of axillary cell) gray. Veins black. Abdomen black; first segment with lateral margins and large markings at posterior angles, second with a semi-elliptical spot on posterior margin and sharply divided into two spots by a median black band, third to fifth with lateral margins beginning beyond middle of third, yellow; venter wholly black. Genitalia small, yellow. Pile of body short, inconspicuous, mostly pale. Length, 12 mm.

*Types*.—Holotype male, paratype male, Iquitos, Peru, F 6062, Feb. 15, 1929 (H. Bassler), Collection Acc. 33591. American Museum of Natural History.

### **Basentidema Macquart**

*Basentidema* Macquart, 1838, Dipt. Exot., I, 1, p. 197; Loew, 1855, Verh. zool.-bot. Ver. Wien, 5: 141.

Close to *Rhaphiocera*; as in that genus, the base of vein  $R_2$  is evanescent and  $R_1$  is weakened or notched at the point of origin of  $R_2$ . Genotype, *Basentidema syrphoides* Macquart, by monotypy.

#### KEY TO THE SPECIES OF BASENTIDEMA

1. Larger species (12 mm.); face black in middle; markings of thorax bluish-green; wings black along costal margin and infuscated at apex; tibiae and apices of tarsi black. . . . . **caerulescens**
- Smaller species (4.5–8 mm.); face yellow; markings of thorax yellow or fuscous; wings uniformly yellowish; legs yellow, bases of coxae and apices of tarsi sometimes black or blackish. . . . . **2**
2. Scutellum two-spined. . . . . **hortulana**
- Scutellum with denticles only. . . . . **syrphoides**

### **Basentidema hortulana** (Wiedemann)

*Sargus hortulanus* Wiedemann, 1830, Auss. Zw. Ins. II, p. 32.

*Hoplistes hortulanus* Williston, 1888, Trans. Amer. Ent. Soc., 15: 251.

Specimens which I have examined agree in every way with Macquart's description and figure of *B. syrphoides*, except for the larger size (7–8 mm.) and the presence of two strong scutellar spines. The two species must be closely related.

Type from Brazil; Williston records it from Rio de Janeiro. I have seen males from Batea, S. Paulo, Oct. and Nov., 1940 (John Lane); Rio de Janeiro, July (S. W. Williston); and Grajahu, Rio de Janeiro, June 20, 1939 (S. Lopes).

### **Basentidema syrphoides** Macquart

*Basentidema syrphoides* Macquart, 1838, Dipt. Exot., I, 1, p. 197.

Length, according to Macquart,  $2\frac{1}{4}$  lines (4.5 mm.). The scutellar spines are reduced to denticles, which, if Macquart's illustration is correct, are set at the outer angles of a rather broad scutellum, broader than in the above species.

Type from Brazil.

### **Basentidema caerulescens** new species

#### Figure 4

A large, black species with attractive bluish-green markings, a definitely spined scutellum, and black tibiae.

*Male*.—Head black, marked with bluish-green as follows: a pair of spots on front, below ocelli; a pair of spots along each eye, reaching from lower part of front almost to oral margin, and expanding inwardly toward each other below antennae; and the occipital orbits almost to lower corner of eyes. Front almost as wide as diameter of an eye. Antennae, including arista, black, second segment, however, brownish; first and second segments and annulated part of third subequal, arista half again length of rest of antennae. Thorax black, marked

with bluish-green as follows: humeri and narrow stripe along each dorso-pleural suture to wing base, where it extends into a broad posterior margin of the mesopleuron and almost touches a large spot of similar color on the sternopleuron; postalar calli and adjacent triangle directed forward; a pair of dorsal stripes broadly separated in front from the humeri and in back from the scutellum and supra-alar calli; scutellum except its narrow base and spines; a large ovoid spot on each metapleuron; and a small one above each hind coxa. Humeri prominent; thorax broadest at wing bases. Coxae, trochanters, tibiae, and last two segments of tarsi black; hind tarsi whitish at base; basal three segments of other tarsi and femora yellow. Halteres green, blackish at base. Wings chiefly grayish hyaline, costal cell and anterior borders of first basal and anal cells black; remainder of basal cells hyaline; veins black. Discal cell short, as high as long, roughly pentagonal; vein  $R_4$  after separation from  $R_5$  bent downward. Abdomen black, marked with bluish-green as follows: a transverse band, broadly separated from sides, on first segment; rectangular markings extending approximately to median third of the segments, on posterior margins of segments two, three, and four; apical half of segment five; and narrow lateral margins beyond middle of second segment. Venter black. Genitalia mostly black, the hypopygium large. Length, 12 mm.

*Female*.—Transverse spots on abdomen smaller, and posterior margin of fifth segment reduced to two small spots; otherwise differs only sexually. The ovipositor is short, blunt, and thick, no longer and almost as stout as the male hypopygium.

*Types*.—Holotype male, Nova Teutonia, Brazil, Nov. 11, 1939 (Fritz Plaumann); American Museum of Natural History. Allotype female, same data but Nov. 10, 1939.

### **Hoplistes Macquart**

*Hoplistes* Macquart, 1834, Suites à Buffon, I, p. 253; Macquart, 1838, Dipt. Exot., I, 1, p. 194; Loew, 1855, Verh. zool.-bot. Ver. Wien, 5: 141; Schiner, 1868, Reise Novara, p. 68; Enderlein, 1914, Zool. Anz., 43: 580; Lindner, 1931, Rev. de Ent., 1: 308.

Several workers (e. g. Williston, Schiner, Lindner) have doubted the distinctness of this genus from *Rhaphiocera*; but these doubts have arisen mainly from the fact that they were comparing *Sargus hoplistes*, and not the genotype, *Sargus bispinosus*, with *Rhaphiocera*. *S. hoplistes* belongs in *Rhaphiocera*; but *S. bispinosus* represents a valid genus.

The wings are long and unusually slender, and the venation is characteristic. The stigma is very short, and vein  $R_{3+4}$ , which arises slightly beyond r-m, runs almost parallel with the apical part of  $R_1$ ;  $R_2$  is developed basally, and  $R_1$  is not weakened at the origin of  $R_2$ ; the submarginal cells are narrow, the first, measured either along the costa or along  $R_{4+5}$ , being twice as long as the second; the discal cell is elongated beyond r-m, but extends but a short distance before it; the posterior veins are strong and extend almost to the wing margin. The legs are long, the basitarsi noticeably so, the hind ones being almost as long as their tibiae; the middle femora, at least in the male, are curved below with numerous small denticles on their entire length.

Genotype, *Hoplistes* (*Sargus*) *bispinosus* (Wiedemann), by original designation.

***Hoplistes bispinosus* (Wiedemann)**

*Sargus bispinosus* Wiedemann, 1830, Auss. Zweifl. Ins., II, p. 32.

*Hoplistes bispinosus* Macquart, 1834, Suites à Buffon, I, p. 253; Macquart, 1838, Dipt. Exot., I, 1, p. 195.

Type from Brazil. I have seen specimens from Mallali, British Guiana (coll. Oldenberg), in the collection of the Deutsches Entomologisches Institut, and from Kamakusa, British Guiana (H. Lang), C. H. Curran Collection No. 31144.

***Rhaphiocera* Macquart**

*Rhaphiocera* Macquart, 1834, Suites à Buffon, I, p. 253; Macquart, 1838, Dipt. Exot., I, 1, p. 196; Loew, 1855, Verh. zool.-bot. Ver. Wien, 5: 141; Schiner, 1868, Reise Novara, p. 68; Osten Sacken, 1886, Biol. Centr. Amer. Dipt., I, 25-27; Enderlein, 1914, Zool. Anz., 43: 580; Lindner, 1931, Rev. de Ent., 1:308.

Genotype, *Rhaphiocera* (*Sargus*) *armata* (Wiedemann), by monotypy.

KEY TO THE SPECIES OF RHAPHIOCERA

1. Abdomen and legs wholly black; vertex, front except just above antennae, and face black; wings deeply infumated with blackish; vein  $R_{3+4}$  long, about three-fourths as long as vein  $R_5$ .....*ornata*  
Abdomen black, with conspicuous lateral margin and cross-bands (interrupted except on first segment) yellow or green; legs largely yellow or green; face, front or both marked with yellow or green, but area immediately above antennae is black; wings hyaline or yellow, or irregularly infumated; vein  $R_{3+4}$  short, not more than half as long as  $R_5$ .....2
2. Submarginal cells broad, the first, measured along radial sector, not more than three times as long as wide; discal cell relatively large, its lower angle (at union with r-m) equidistant from anterior and posterior wing margins; wings hyaline or uniformly yellow; front with two yellow spots below antennae; legs without conspicuously blackened segments (other than tarsi).....3  
Submarginal cells long and narrow, the first four or five times as long as wide; discal cell smaller, its lower angle much nearer to anterior than to posterior margin; wings more or less clouded; front usually black above, sometimes marked with yellow; tibiae black. A variable species, with several named varieties.....*armata*
3.  $R_1$  thickened beyond separation from  $R_2$ ; wings short; the break in  $R_1$  at origin of  $R_2$  not clearly evident; interrupted abdominal cross-bands linear; scutellum black at base.....*hoplistes*  
 $R_1$  not thickened; wings longer;  $R_1$  clearly weakened at origin of  $R_2$ ; interrupted abdominal cross-bands triangular; scutellum wholly pale.....*sancti-pauli*

***Rhaphiocera ornata* Macquart**

*Rhaphiocera ornata* Macquart, 1846, Dipt. Exot., suppl. 1, p. 55.

*Hoplistes ornatus* Enderlein, 1914, Zool. Anz., 43: 580.

Enderlein referred this species to *Hoplistes* because of the elongation of the first submarginal cell; however, this elongation is to be found along the radial sector, not the costa, and is due to the elongation and slope of  $R_{3+4}$ . The discal cell, in the Ambato, Ecuador, specimens, is elongated basally; this character, however, is probably variable, though it may serve as a distinction of a separate species.

Type from Colombia. Recorded by Enderlein from Ecuador. Ecuador: Ambato, 2 ♀. Bolivia: Prov. Sara (Steinbach).

**Rhaphiocera armata** (Wiedemann)

*Sargus armatus* Wiedemann, 1830, Aus. Zweifl. Ins., II, p. 29.

*Rhaphiocera armata* Macquart, 1838, Dipt. Exot., I, 1, p. 196; Schiner, 1868, Reise Novara, p. 68; Williston, 1888, Trans. Amer. Ent. Soc., 15: 251; Enderlein, 1914, Zool. Anz., 43: 580; Lindner, 1931, Rev. de Ent., 1: 308; Lindner, 1935, Rev. de Ent., 5: 399.

A highly variable species. Lindner (1931) illustrated and tabulated five varieties, namely *hansae*, *minaensis*, *stieglmayri*, *borgmeieri*, and *trans-hansae*; later (1935) he added a sixth, *zikani*. Of these, I have seen only the typical form, *hansae*, and *zikani*. Lindner's table and illustrations will serve better than any key to separate the varieties.

Recorded by Wiedemann, Macquart, Williston, Enderlein, and Lindner from various localities in Brazil.

**Rhaphiocera hoplistes** (Wiedemann)

*Sargus hoplistes* Wiedemann, 1830, Aus. Zw. Ins., II, 30.

*Rhaphiocera hoplistes* Schiner, 1868, Reise Novara, p. 69.

*Hoplistes hoplistes* Kertész, 1909, Catalogue; Lindner, 1931, Rev. de Ent., 1: 305, 309-10.

Known only from Brazil.

**Rhaphiocera sancti-pauli** Lindner

*Rhaphiocera sancti-pauli* Lindner, 1931, Rev. de Ent., 1: 309-10.

Type from São Paulo, Brazil. Brazil: Cotia, São Paulo, Dec. 27, 1940 (A. G. Silva); M. das Cruces, São Paulo, Jan., 1939 (M. Carrera); Ypiranga, São Paulo, Dec. 29, 1939 (E. Salim).

The following species are not known to me, but quite probably belong in this genus. (*Rhaphiocera*?) *brevis* Bigot, from New Caledonia, certainly does not belong here.

*R. bipartita* Macquart, 1846, Dipt. Exot., Suppl. I, p. 54; from Colombia (= *R. bipartita* Walker).

*R. caloptera* Osten Sacken, 1886, Biol. Centr. Amer. Dipt. I, p. 26; from Mexico.

*R. pampina* Osten Sacken, 1886, Biol. Centr. Amer. Dipt. I, p. 25; from Panama.

*R. picta* van der Wulp, 1879, Ann. Soc. Ent. Belgique, 22, Comp. Rend., 46; from Brazil.

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# STUDIES IN NEOTROPICAL STRATIOMYIDAE

(Diptera)

## VI. A NEW GENUS RELATED TO ADOXOMYIA

MAURICE T. JAMES,  
Colorado State College,  
Ft. Collins, Colorado

Collections of Stratiomyidae sent to me by Dr. H. de Souza Lopes of the Instituto Oswaldo Cruz and Dr. C. H. Curran of the American Museum of Natural History contained series of the interesting new genus described in this paper.

### **Leucoptilum** new genus

Antennae much longer than head, ten-segmented; first two segments conical, largest apically, subequal, the first slightly the longer; third to eighth segments forming a fairly compact unit; ninth cylindrical, densely pilose; tenth slender, elongated, densely pilose. Eyes pilose, contiguous in male. Occipital orbits well-developed above in female, evanescent above in male and below in both sexes. Thorax broadest at wing bases, thence tapering both anteriorly and posteriorly; scutellum with two strong spines. Abdomen broader than thorax, somewhat longer than broad. Legs of usual length.  $R_{2+3}$ ,  $R_4$  and  $r-m$  present; discal cell pentagonal, contact with fifth posterior cell usually punctiform, or sometimes a distinct  $m-cu$  crossvein present. Genotype, *Leucoptilum plaumanni* James, new species.

Related to *Adoxomyia*, from which it may easily be distinguished by the antennal structure, particularly the greatly elongated and pilose terminal segment (compare figures of Kertész, 1923, Ann. Mus. Nat. Hung., vol. 20, pp. 99 and 105, and Lindner, 1938, Die Fliegen der Pal. Reg., fasc. 18, p. 154). The general appearance is closer to some species of *Cyphomyia*; in fact, particularly in consideration of the occasional presence of  $m-cu$ , this may be a form intermediate between the two genera.

### **Leucoptilum plaumanni** new species

Figures 1 and 2

*Female*.—Head shining black. Front coarsely punctured; at anterior ocellus half again as wide as at antennae; elevated in the middle, more depressed along ocular margins, but with a distinct polished, angularly margined elevation to each side of the antennae. Vertex separated from occipital orbits by a distinct groove; occipital orbits angular behind. Face small, parallel-sided. Proboscis and palpi yellow. Pile of head rather sparse, mostly appressed except on the face, whitish; that of eyes short, black. Antennae mostly black; segments three to six or seven may be more or less reddish; segment ten, except narrow base, yellow to white; pile black, except on yellow

parts of segment ten, where it is white; segment three devoid of pile, four or five to seven with definite semi-erect pile at base of each segment, eight more extensively pilose, nine and ten densely pilose; ratio of segments 5 : 4 : 4 : 3 : 4 : 3 : 4 : 5 : 8 : 23. Thorax shining black; pile fairly abundant, short, semi-appressed, yellowish on dorsum, more whitish on pleura and scutellum; scutellum triangular, spines about half length of scutellum, slightly incurved and yellowish at extreme apex. Halteres yellow. Legs mainly yellow; front femora brownish medially, middle ones brown on apical half, hind femora and tibiae black on apical half or more; hind tarsi white. Tarsi pale-pilose.

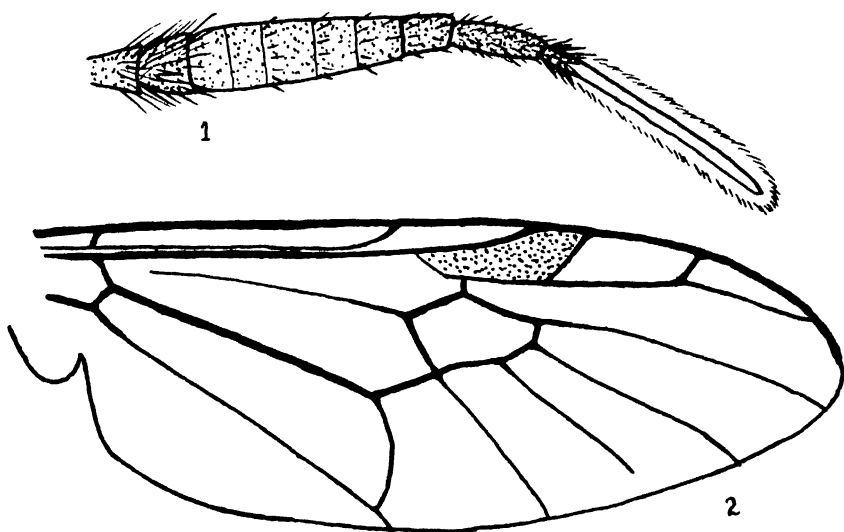


FIG. 1. *Leucoptilum plaumanni* James, antenna of holotype ♀.

FIG. 2. *Leucoptilum plaumanni* James, wing of holotype ♀.

Wings uniformly smoky brown, stigma and veins blackish brown; stigma and cell  $R_1$  about as broad as basal cell; vein  $R_1$  bent slightly downward after separation from  $R_2$ . Abdomen oval, slightly longer than broad, black, shining, with inconspicuous, short, black pile and with longer whitish pile on sides and venter. Length, 6-7 mm.

*Male*.—Antennae more slender; ratio of segments 4 : 3 : 2 : 2 : 3 : 2 : 3 : 5 : 8 : 18; densely black-haired beyond the base of the seventh, only the tip of the tenth being white-pilose. Face and frontal triangle small. Thorax with abundant, erect, pale yellow pile. Front and middle femora pale brownish; hind femora as in female; hind tibiae and basitarsi mainly brownish black; hind basitarsi enlarged, as thick as their femora, two thirds length of their tibiae, and as long as the remaining tarsal segments combined. Abdomen more slender, three-fifths as wide as long, pile more conspicuous, with much black pile on sides of fourth and fifth segments. Genitalia small. Otherwise as in female.

*Types*.—Holotype female, Nova Teutonia, Brazil, Feb. 24, 1938 (Fritz Plaumann); Collection of the Instituto Oswaldo Cruz. Allotype male, Nova Teutonia, Dec. 6, 1936, (Plaumann); American Museum of Natural History. Paratypes: 3 females, Nova Teutonia, Jan. 5, 1938, Feb. 10, 1938, and no date (Plaumann); 1 female, Angra dos Reis, Japuhuba, E. do Rio, Brazil (Trav. et Lopes); 1 female, Rio de Janeiro, Jardim Botânico (H. S. Lopes). Collections of the Instituto Oswaldo Cruz, the American Museum of Natural History, and the author.

#### *Leucoptilum bassleri* new species

*Female*.—Differs from *plaumanni* as follows: Pile of head denser; that of eyes inconspicuous, visible only under high magnification. Antennae as in *plaumanni*, but eighth segment more clearly separated from the preceding ones, and as conspicuously pilose as the ninth, and tenth black-pilose on basal third. Thorax with longer and denser pile, which is almost woolly and from certain angles conceals the ground color on dorsum and scutellum; scutellar spines two-thirds length of scutellum, yellow. Legs yellow; sub-apical ring of front and middle femora, and apical half of hind femora and tibiae, brown; hind basitarsi black-pilose. Infumation of wings almost uniform, but slightly less intense in first submarginal cell and toward basal half of wing. Length, 6.5 mm.

*Type*.—Holotype female, Lower Rio Tapiche, Peru, Aug. 23, F 6020 (H. Bassler Collection, Acc. 33591); American Museum of Natural History.

THE MICROSCOPE AND ITS USE, by FRANK J. MUNOZ and HARRY A. CHARIPPER. Pages xii+344, 6 x 8 $\frac{3}{4}$  inches, 122 figures. Published by CHEMICAL PUBLISHING COMPANY, INC., Brooklyn, New York. 1943. Price, \$2.50.

The senior author of this book has for many years been connected with one of the large manufacturers and distributors of microscopes, and in this capacity has been called upon to solve many problems of various users of microscopes; the junior author is a professor of biology at New York University with many years of experience in laboratory research and teaching. These two men have collaborated to produce a comprehensive book on the use and care of the microscope, written in non-technical language. The book is not intended as a scientific treatise but as a guide to aid students and technicians in the use of this instrument.

The table of contents gives an idea of the scope of the book: I, The Evolution of the Microscope; II, The Modern Microscope; III, Illumination; IV, The Microtome; V, The Use and Care of the Microscope; VI, The Stereoscopic Microscope; VII, The Metallurgical Microscope; VIII, The Polarizing Microscope; IX, Accessories for Use with the Microscope; X, Common Errors in the Use of the Microscope; the remaining pages contain a table of magnifications, drawings illustrating the optics of a microscope, a glossary, bibliography, and index.

This is an excellent book for anyone who uses a microscope. It contains a great deal of practical information, and answers many questions that arise in the use and care of various types of microscopes and their attachments. It is written in clear, simple language, and is well illustrated. The advice it gives should lead to a more efficient use of the microscope.—D. J. B.

# BIOLOGY OF THE IMMATURE STAGES OF THE CLEAR LAKE GNAT

(Diptera, Culicidae)

CHRISTIAN C. DEONIER,

United States Department of Agriculture,  
Bureau of Entomology and Plant Quarantine,  
Nice, California

The Clear Lake gnat, *Chaoborus astictopus* D. and S., is a non-biting gnat of the family Culicidae. The species is known as the Clear Lake gnat because these insects breed in large numbers in the environs of Clear Lake, Calif. Studies from 1939 to 1941 on the life history and morphology of the immature stages of this gnat are reported herein.

## LIFE HISTORY

Life-history studies of *Chaoborus astictopus* were conducted under controlled conditions and, when possible, under lake conditions. In 1937 Herms gave a brief resume of the life history of this species. A more detailed study by Lindquist and Deonier (manuscript) showed that adults began emerging in large numbers in the spring from the overwintering larvae at water temperatures of 62° to 70° F., but that during the fall pupation and emergence were greatly reduced at 70° and nearly ceased at 65°. The adults emerged between 11 p. m. and 6 a. m.; the sex ratio was 60.2 per cent males and 39.8 per cent females. The adults were found to have a preoviposition period of 36 to 48 hours or more which was spent on shore in bushes and trees. These authors also report on the flight habits and oviposition which begin at dusk. The eggs were found to be white when deposited but they turned brown over night. Hatching, on the surface and under water, usually occurred in 20 to 24 hours during the summer, although under some conditions a longer time was required.

The newly hatched larvae, which escape from the egg chorion through a longitudinal slit on the side in contact with the water, were free-swimming; apparently they did not migrate to the bottom mud of the lake during the daytime as did the later instars, as they were collected by the thousands with a plankton net. Information is difficult to obtain on the length of the developmental periods for the immature *Chaoborus* larvae in the lake because of the long-drawn-out periods of emergence and the overlapping broods of larvae. The only opportunity offered for such a study is early in the spring, especially if a heavy oviposition occurs, followed by a period unfavorable for the adults and further oviposition. Even then development could be followed only through the third instar since the fourth instars could not, with certainty, be distinguished from the overwintering larvae.

In May 1940, when the water temperature was 63° F., newly hatched larvae were not observed to feed until 3 days after hatching. The developmental period for the first instar in the lake was over

8 days. The shortest period of development from egg to fourth instar was 18 days.

In the laboratory the length of the first three stadia was determined at 70° and 80° F. (Table I), the instars in these cultures being determined by examining 10 larvae taken at random. The first stadium was abnormally long since food was not offered until the larvae were 4 days old. These stadia, which usually required from 8 to 15 days, were prolonged when temperature and food conditions were unfavorable; and extended periods of unfavorable conditions resulted in death of the larvae. The early instars developed more slowly at 70°, but the development of the third instar was just as rapid at 70° as at 80°.

TABLE I

DURATION OF LARVAL STADIA OF *Chaoborus astictopus* AT 70° AND 80° F.  
Eggs laid October 10, 1940, hatched October 11, larvae first given  
plankton October 15

AGE (days)	At 70° F.				At 80° F.			
	First Stadium	Second Stadium	Third Stadium	Fourth Stadium	First Stadium	Second Stadium	Third Stadium	Fourth Stadium
	<i>Days</i>	<i>Days</i>	<i>Days</i>	<i>Days</i>	<i>Days</i>	<i>Days</i>	<i>Days</i>	<i>Days</i>
7	10	.....	.....	.....	10	.....	.....	.....
8	10	.....	.....	.....	7	3	.....	.....
9	8	2	.....	.....	.....	10	.....	.....
10	7	3	.....	.....	.....	9	1	.....
11	.....	.....	1 <sup>1</sup>	.....	.....	5	5	.....
12	1	8	1	.....	.....	4	6	.....
13	2	7	1	.....	.....	3	7	.....
14	.....	.....	.....	.....	.....	.....	.....	1 <sup>2</sup>
15	.....	4	6	.....	.....	1	8	1
16	.....	1	8	1	.....	.....	6	4
17	.....	2	4	4	.....	.....	5	5
20	.....	.....	2	8	.....	.....	1	8
22	.....	.....	.....	10	.....	.....	.....	10

<sup>1</sup>Third instar found upon examination of more mature larvae in culture.

<sup>2</sup>Fourth instar found upon examination of more mature larvae in culture.

The fourth stadium is extremely variable in length. In the laboratory under optimum conditions it has been as short as 2 days and as long as 9 months. Development was checked and pupation prevented by either lowering the temperature to below 60° F. or withholding food. In several instances larvae lived for two to three months at low temperatures without food.

With an abundance of plankton and temperatures of 70° to 80° F. the larval period lasted from 11 to 25 days (Table II).

Overwintering larvae from the lake were forced to pupate during the winter by placing them in a medium at 70° to 80° F. and offering them an abundance of plankton containing Copepoda. The time required to get pupation in the laboratory from overwintering larvae decreased from 24 to 8 days as spring conditions developed (Table III).

The pupal period was from two to three days, usually two days. In repeated breeding-jar tests pupae which did not develop into adults in this time died. This period is similar to that found for *Chaoborus punctipennis* (Say) by Muttkowski (1918). The actual process of emergence of adults was observed on repeated occasions. The adult freed itself from the pupal skin in a few seconds and was capable of flying almost immediately, but if undisturbed it usually paused for a few minutes on the cast skin.

Male pupae (fig. 2) are distinguished readily from female pupae (fig. 1) by the sheathed male terminalia, in which the clasper is clearly visible, located ventrad of the anal fin.

TABLE II

LENGTH OF LARVAL STAGE OF *Chaoborus astictopus* AT 70° TO 80° F.  
WHEN FED AN ABUNDANCE OF PLANKTON

DATE EGGS HATCHED	DATE PLANKTON FIRST OFFERED	LENGTH OF LARVAL STAGE		
		Minimum	Maximum	Mean
		<i>Days</i>	<i>Days</i>	<i>Days</i>
April 28, 1940.....	May 1, 1940.....	15	25	19.2
April 26, 1940.....	April 27, 1940.....	15	24	19.1
April 29, 1940.....	April 30, 1940....	13	21	14.1
April 30, 1940.....	May 1, 1940.....	11	22	14.5
May 2, 1940.....	May 2, 1940.....	14	22	18.4

TABLE III

LENGTH OF TIME REQUIRED TO BREAK THE OVERWINTERING STAGE OF  
*Chaoborus* LARVAE UNDER LABORATORY CONDITIONS

DATE LARVAE WERE TAKEN FROM LAKE	DATE PUPATION BEGAN	NUMBER OF DAYS
October 23, 1939.....	November 16, 1939.....	24
December 18, 1939.....	January 2, 1940.....	15
February 12, 1940.....	February 24, 1940.....	12
March 5, 1940.....	March 16, 1940.....	11
March 19, 1940.....	March 27, 1940.....	8

### DESCRIPTION OF THE LARVAL INSTARS

Four instars were found with characters based on slight modifications of the mouth parts and anal fin, by which they could be recognized.

*First instar.*—The first instar, or newly hatched larva, has raptorial antennae. The postantennal filaments are absent. The prelabral leaflike appendages are present. The mandibles are well developed, but the mandibular fans are absent. The eyes are simple.

*Second instar.*—In the second instar the postantennal filaments are present. The mandibular fans are formed and have 6 or 7 rays, more

frequently 6. The eyes are simple. The anal fin has 12, 13, or 14 rays, usually 14.

*Third instar.*—The third instar has all the structures of the previous instars. The eye is simple in the early part of the third stadium, but frequently development of the compound eye is begun toward the end of this stadium. There are 10, 11, or 12 rays in the mandibular fan. The anal fin may have 15, 16 or 17 rays, but 16 rays are by far the most common. Of the 45 larvae examined, 38 had 16 rays in the anal fin.

*Fourth instar.*—The fourth instar, or mature larva, has 5 spines on each raptorial antenna, with the outer spines on each side slightly shorter than the middle 3. Ventrally, between the antennae and the labrum, are 5 pairs of postantennal filaments and 2 prelabral, leaflike appendages which are narrow lanceolate, the hairs on the anterior side giving them a serrate appearance. The labrum is cylindrical and elongated. The mandibles have 3 large, stout teeth and 2 smaller teeth with a spinelike tooth in the area between the smaller and larger teeth. The number of rays in the mandibular fan may range from 13 to 20. Fifteen rays are most commonly found. The number of rays in the anal fin may range from 15 to 20, but usually there are 18. Thirty out of 39 larvae examined had 18 rays in the anal fin. The development of the compound eyes is completed soon after this stadium is reached. Mature larvae are from 8 to 10 mm. in length. The structures of a mature larva are shown in figure 3.

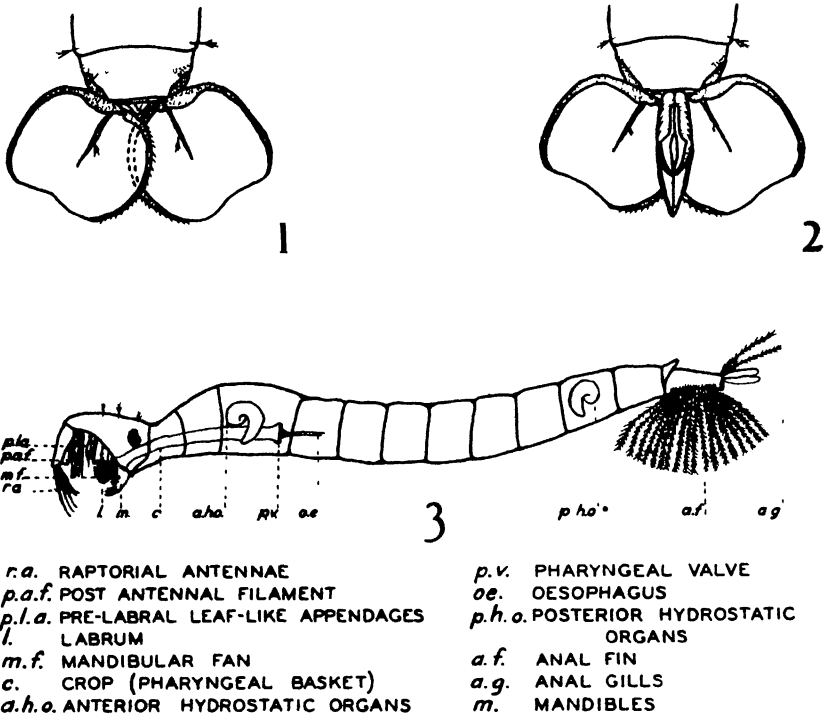
#### SYSTEMATIC RELATIONSHIPS

According to Johannsen (1934) the larvae of the genus *Chaoborus* resemble one another closely, differing chiefly in slight modifications of mouth parts and the anal fin. In the key for the larvae given by Johannsen, *C. astictopus* would come close to *C. punctipennis* var. *b*. Since larvae of other species were not examined by the author, a comparison could not be made. The number of rays in the mandibular fan of *C. astictopus* taken in Lake County, Calif., is especially variable. Larvae taken in May 1940, from Lake Pillsbury were found usually to have 20 or more rays. One specimen had 15 rays in one fan and 22 in the other. The number of rays in the mandibular fan of 12 larvae taken from Blue Lakes March 7, 1941, ranged from 15 to 20 as follows: 15 rays, 1; 17 rays, 1; 18 rays, 6; 19 rays, 2; 20 rays, 2. In ten larvae taken from Clear Lake March 13, 1941, examined, the number of rays in the mandibular fan ranged from 15 to 20 as follows: 15 rays, 6; 16 rays, 2; 17 rays, 1; 20 rays, 1. In Germany Peus (1934) found *Chaoborus* larvae to be variable, and he considers the prelabral leaflike appendage the most reliable character for separating the species. In individual larvae no relationship of these variations with similar variations in previous instars was indicated, since the appendages of each instar are formed against the body or in the head capsule, independent of previous structures which continue functioning until molting occurs.

#### FOOD HABITS

Klugh (1927) reports that larvae of the genus *Chaoborus* are enemies of entomostracans. In the laboratory he observed them devouring *Cyclops fuscus*, *Simocephalus serrulatus*, and *Ceriodaphnia reticulata*.

In discussing a paper by Knab (1909) presented at a meeting of the Entomological Society of Washington, Dyar stated that the larvae of *Chaoborus punctipennis* were very destructive to mosquito larvae in puddles near Washington, D. C. Muttkowski (1918) found the food of the species to be small worms and various components of plankton, specifically *Volvox*. Herms (1937) reports the larval food of *C. astictopus* to be algae and small aquatic animals and, in captivity, one another.



*Chaoborus astictopus*: Figure 1, terminalia of ♀ pupa; 2, terminalia of ♂ pupa; 3, mature (fourth instar) larva.

The examination for food habits of the almost transparent larvae with its peculiar pharyngeal basket is relatively simple. The predaceous larva forces the whole captured organism into this basket, or crop, where mastication occurs. The contents of the crop can be emptied for identification by gentle pressure with a dissecting needle. Larvae were observed to empty the pharyngeal basket by reverse peristalsis, but the everting of the basket, as stated by Burgess and reported by Herms (1937), was not observed except in injured specimens.

Newly hatched larvae of *Chaoborus astictopus* were found to feed almost entirely on rotifers, primarily *Anuraea cochlearis* Gosse. Twenty larvae examined from the lake had this rotifer in their crops, although larvae were taken which had fed on other species of Rotifera. A.



*cochlearis* was the predominating species in Clear Lake, which may account for the high percentage of larvae feeding on this species. *Notholea* sp. was abundant in plankton samples from Blue Lakes in the spring of 1940, and first instars were found feeding on this rotifer. A newly hatched larva was found attempting to swallow an immature copepod. Although some Copepoda may be eaten by first instars, the size of most Copepoda would preclude their extensive use as food by this instar. On one occasion a larva was observed with phytoplankton in its crop.

The second instars fed on immature Copepoda and Rotifera. Eleven second instars taken from the lake had copepods in their crops. Four were found with rotifers.

Third instars were found to have the same food habits as the mature larvae. Nineteen individual specimens examined from the lake were found to be feeding on Copepoda.

The fourth instar, or mature larvae, feed upon Copepoda, chiefly *Cyclops* sp. and *Diaptomus* sp., both mature and immature forms. Tests were made in the laboratory on the kind and quantity of organisms ingested. Where larvae were permitted to select organisms at random from an abundant supply of Clear Lake plankton, *Cyclops*, *Diaptomus* and occasionally *Bosmina* were selected, and *Daphnia* was rarely taken. In feeding tests where the food supply was limited, larvae ingested *Daphnia*, blood worms, yeast cells, and Infusoria. The last two were probably taken accidentally while other organisms were being ingested. Dead organisms were refused.

In a feeding test on 20 overwintering larvae an average of 6.7 Copepoda were eaten. The same group ate an average of 8.3 Copepoda the following day. The number eaten depends on the size of the plankton organism. When food was abundant, larvae were observed to capture 12 *Cyclops* in 45 minutes. In the lake they are undoubtedly periodic feeders, since they are in the bottom mud during the day and migrate up into the lake at night.

Mature larvae feed readily upon small mosquito larvae offered them. The larvae are cannibalistic in all stages when the food supply is deficient.

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# CAECULUS PETTITI, A NEW SPECIES OF MITE FROM VIRGINIA

F. REESE NEVIN,

Cornell University, Ithaca, N. Y.

Banks (1899) described *Caeculus americanus* from two specimens collected at Palm Springs, California; the only other species of this genus that has been described from the United States is *Caeculus clavatus* (Banks, 1905), collected from among leaves near Washington, D. C. I have examined the type specimen of this latter species, and Jacot's material that is deposited in the Museum of Comparative Zoology at Cambridge, Massachusetts.

For a complete bibliography of the genus, see Jacot (1936).

*General Characters of the Genus.*—The arrangement of the larger setae on the legs, especially on the large first and second pairs of legs reminds one of the arrangement of the teeth in a wooden hand-rake, hence the name "rake-legged" mites. The number and the arrangement of these setae and of the smaller club-shaped or spatula-shaped setae on the legs and on other parts of the body are important taxonomically and in differentiating the various stages in the life history of the mite. There is, however, some variation in the number of setae as will be noted in the accompanying figures where, in some cases, a seta is present on one side of the body but is lacking on the other side. Nevertheless, the arrangement and numbers of setae are quite constant within the species.

The flattened dorsal surface with a series of sclerotized plates separated by wrinkled cuticula, the presence of large eyes, and of spatula-like digits of the chelicera, are also generic characters.

## *Caeculus pettiti* new species

Figures 1 and 2

Well sclerotized specimens are brown to black in color. Specimens not so well sclerotized are very light brown in color or are colorless, as are the unsclerotized areas of the cuticula of the colored specimens and of the larvae and most of the nymphs.

The size and shape of the body vary quite extensively, depending upon the degree of distention of the abdomen. When fully distended the wrinkles or folds in the cuticula between the various plates are somewhat smoothed out. The dorsal surface is in general quite flat, and the ventral surface somewhat more rounded in the region of the genital and anal plates.

Figures 1 and 2 of the dorsal and ventral surfaces respectively, show the areas of heavy sclerotization or plates.

*The Dorsal Surface* (fig. 1).—There are six dorsal and two postero-dorsal plates. The latter are only slightly colored and are not at all discernible in most specimens. The dorso-cephalic plate covers the entire capitulum and, as seen from above, extends posteriorly upon the notothorax to a point between the second and third pairs of legs.

This plate is heavier anteriorly and laterally, leaving a less heavily sclerotized area extending from the center of the plate to the transverse groove at the anterior edge of the median-dorsal plate. The cephalic plate bears 4 pairs of setae; one near the anterior margin,

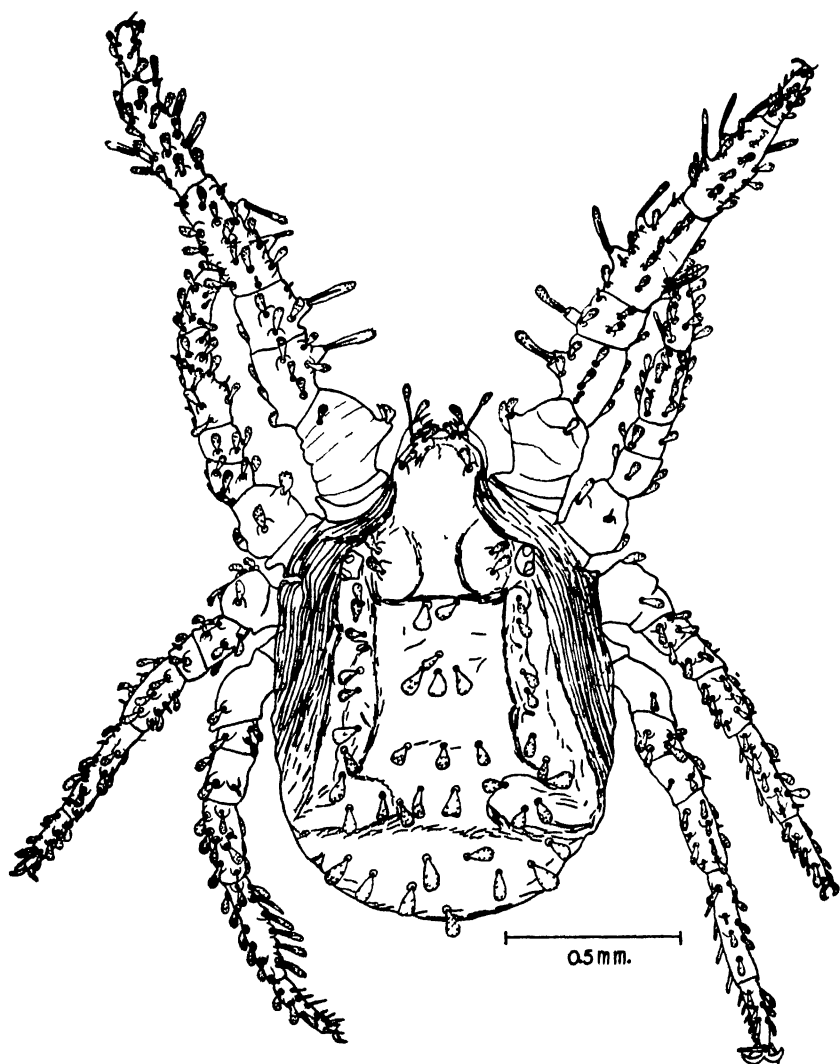


Figure 1. Dorsal view of adult *Caeculus pettiti*, n. sp

one near the antero-lateral margin and the other two pairs in a postero-lateral position.

Beneath the cephalic plate is another plate which bears what appear to be pseudostigmatic organs. Pseudostigmatic organs are

generally not found in this position. The palpi in some specimens are not visible dorsally, but are concealed under the cephalic plate. In other specimens they appear as four-segmented structures with a digit attached jointly with the last segment.

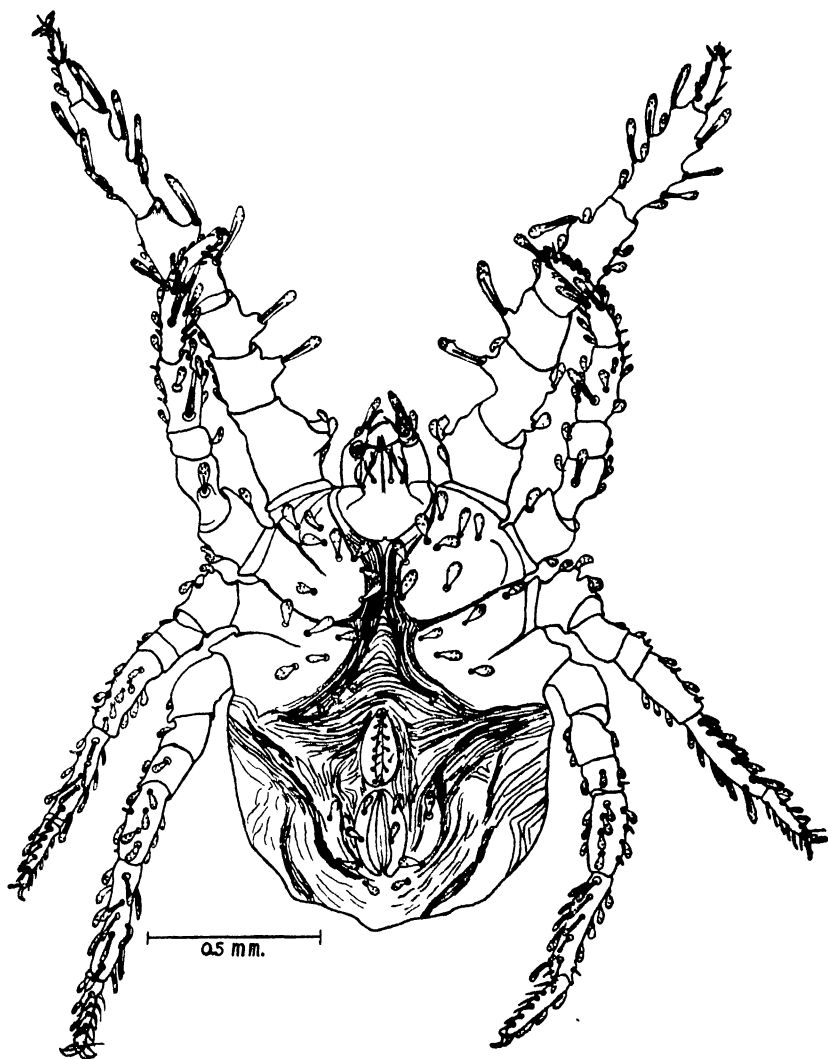


Figure 2. Ventral view of adult *Caeculus pettisi*, n. sp.

The median-dorsal plate is roughly square in outline, being slightly longer than broad, and broader posteriorly than anteriorly. The posterior margin of this plate may not be readily distinguishable since sclerotization may be no more complete than in posterior areas.

On this plate there are three rows of broad-tipped setae; the first row consists of one pair of setae, the second row, an irregular one of 3 or 4 setae, the third row of 2 or 3 setae near the posterior edge of the plate. Just posterior to this plate is another row of 3 setae. On either side of the median-dorsal plate is a narrow plate about four times as long as broad. Each of these plates bears 7 or 8 setae arranged in groups of 2 or 3, 2, and 3. Between each of these groups of setae are deeper grooves or openings in the heavy cuticula.

The eyes are located just opposite the two pairs of setae in the posterior region of the cephalic plate and are thus opposite the base of the second pair of legs. The eyes are divided, each part being covered with a heavy cornea. The location of the eyes is such as to give them a dorsal position in some specimens and a dorso-lateral position in other specimens depending upon the mounting of the specimen.

Caudad and mesad from the dorsolateral plate is a plate nearly oval in shape bearing three pairs of setae. This plate is distinct in some specimens, less so in others. Between the latter plates there are the three spatula-shaped setae mentioned above. Posteriorly are found at least four more pairs of setae and, in heavily sclerotized specimens, two postero-dorsal plates previously mentioned.

*The Ventral Surface* (fig. 2).—On the ventral surface there is a very definite genital plate bearing 7 pairs of short sharp spine-like setae. An anal plate with 2 pairs of club-shaped setae and a pair of lateral anal plates with one pair of club-shaped setae are present. The genital and anal plates are close together with no ventral plate between them.

The other sclerotized areas on the ventral surface are the flattened coxal plates, and the ventral surface or lower lip of the capitulum. I am not prepared to state what is the true nature of the structures which I have called coxal plates. I have previously (Nevin, 1935) described much narrower structures in *Cnemidocoptes mutans*, following the work of Buxton (1921), as epimeres. This term is also applied by Thor (1931). Jacot (1936) used the term parasterna as synonymous with epimera. Banks (1904) used the term coxa for these structures. Vitzthum (1933) used the term "coxalflächen" which I assume may be translated to mean coxal plates as well as coxal surfaces. These plates may correspond to enlarged sternopleurites of insects (Snodgrass, 1935). Coxal plates I and II are closely joined together as are III and IV. The first two bear 8 pairs of setae, the latter two 5 pairs of setae. In the midline between the right and left coxal plates are grooves or lines in the cuticula. In the drawing it was not possible to include all of these. The region between the genital plate and the fourth coxal plates bears a few setae which are rather hard to make out and which also appear inconstant in position in different specimens because of the wrinkled nature of the cuticula.

The lower lip bears 2 pairs of setae, the posterior pair long and quite slender, the anterior pair small. The chelicerae are located dorsal to this structure and may be seen through it. The digits of the chelicerae are shown in figure 2, and the body of the chelicerae are shown by means of dotted lines in figure 1. Dorsally or ventrally the

digits appear spatula-shaped ending in a chisel-like point. In lateral view the digit is sickle-shaped.

*The Legs.*—The accompanying drawings show the arrangement of the setae on the legs. The conspicuous structures of the first two pairs of legs are the large rake-tooth type of club-shaped setae. These are very heavy setae with a central dense, orange-colored structure. They terminate in a knob. These setae are set in wells in protuberances on the various segments of the legs. The arrangement of these setae on the segments of leg 1 is as follows: the large basal segment (described by Vitzthum as the trochanter and by Jacot as the coxa-trochanter) and the next distal segment bear one seta each on their mesal surfaces, the next distal segment bears two setae on the mesal surface and one on the distal or outer surface, the tibia bears three setae on the mesal surface and three on the outer surface. The tarsus bears none of the heavy type of setae but ends in two heavy claws. The other spatulate bristles and the smaller sharp bristles are accurately represented in the drawings. In some areas bluntly pointed setae seem to be arranged in rows with the spatulate setae. Where not symmetrically arranged these blunt setae may represent the cores of the spatulate setae.

Length, 1.3–1.44 mm.; average for four individuals, 1.37 mm.

This description of *C. pettiti* is based upon a study of 3 adults, sent to me by Dr. Lincoln C. Pettit of Washington and Lee University from Elk Creek, Grayson County, Virginia, and from a single adult from Lexington, Virginia. In these collections there were 11 nymphs and 13 larvae. These are of sufficient interest to warrant later description.

A potassium hydroxide treated specimen from Elk Creek is designated the type for the species. The drawings (figs. 1 and 2) were made from this specimen. The outline and as many of the details as possible were made under the camera lucida. It was necessary to study such details as the spines under the oil immersion objective. Some of the spines may thus be slightly exaggerated in size in the drawings.

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## A NEW SPECIES OF POLYBIA FROM PANAMA

(Hymenoptera, Vespidae)

J. C. BEQUAERT,

Museum of Comparative Zoölogy,  
Cambridge, Mass.

### ***Polybia barbouri*, new species**

Figure 1, A-F

A medium-sized black wasp, with the clypeus, propodeum, post-scutellum and sometimes scutellum yellow. Wings mostly hyaline. Oculo-malar space obsolete. A fine humeral collar; no distinct propodeal groove. Genae and vertex separated from occiput by a raised line. Clypeus broader than high. Basal stalk of first tergite moderately long, passing gradually into the much wider apical portion.

*Female*.—Head moderately swollen, slightly wider than the thorax; seen in front, much wider than high; seen from above, broadly rectangular and a little over two and a half times as wide as long; occipital margin strongly curved inward. Upper half of gena (outer orbit) margined behind by a very fine raised line (placed rather far back) which continues between the vertex and the occiput. Genae well developed, in profile about two-thirds the width of the eye, somewhat swollen in upper third. Oculo-malar space very short, the eye almost touching the mandibular condyle. Inner orbits farther apart on the vertex than at the clypeus. Ocelli rather large, close together in an equilateral triangle; posterior ocelli three times as far from the inner orbits as from each other. Interantennal shield slightly raised, flattened medially, with a fine, short, impressed longitudinal line in the upper part; frons not appreciably swollen. Clypeus about one and one-third times as wide as high, transversely pentagonal, with all sides about equal, contiguous to the eyes over about one-half of the sides; anterior margin moderately produced into a broadly obtuse angle, with a blunt point. Mandibles and antennae as usual. Thorax about one and a third times as long as high in profile; pronotum evenly curved anteriorly, dorsally with a distinct but low and very finely carinate humeral ridge, which is very broadly interrupted medially; humeral angles not in the least projecting; pleura as usual; mesonotum longer than wide, semi-elliptical anteriorly; scutellum and postscutellum rather strongly swollen, with deep sutures; propodeum rather short and broad, without groove or concavity, medially with a very weak raised line over apical two-thirds. First abdominal segment elongate pear-shaped seen from above, about one and a half times as long as its greatest apical width, about two-thirds the length of the second tergite in profile; basal third forming a parallel-sided stalk, about one-fourth the width of the apical portion which widens gradually behind the stalk; spiracles not projecting; in profile the wider apical portion is little swollen and slants gradually to the stalk. Legs and venation as usual.

Dull, except over median slope of propodeum, clypeus and mandibles. Entirely covered with microscopic, alutaceous sculpture, nearly impunctate. Preapical portion of clypeus and mandibles with a few, widely spaced medium-sized punctures. An extremely short, somewhat silvery pubescence; longer erect hairs very few, particularly over apical area and at apical margin of clypeus, on the mandibles and (very sparsely) on the sides of the propodeum. Eyes bare.

Black, conspicuously marked with pale sulphur-yellow as follows: clypeus (sometimes with irregular brownish blotches in the upper median area); lower inner orbits and most of frons below antennae;

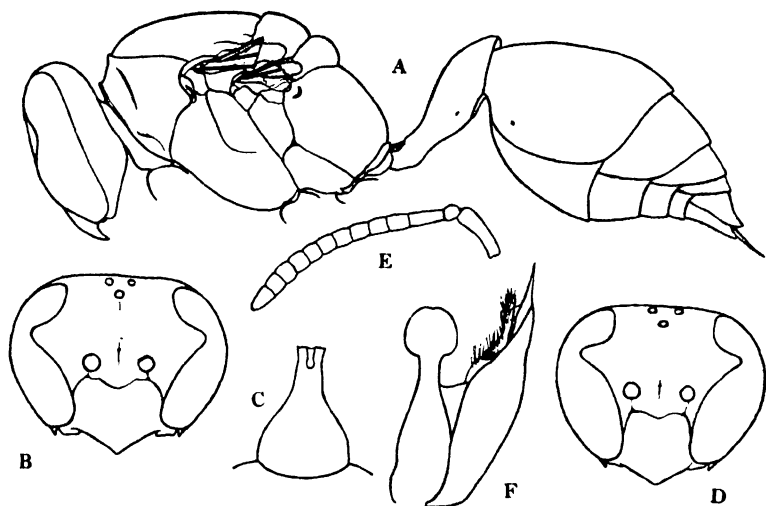


FIGURE 1. *Polybia barbouri*, new species. A-C, female holotype; A, body in profile; B, head in front view; C, first tergite of abdomen from above; D-F, male allotype; D, head in front view; E, antenna; F, terminalia.

a spot over basal third of mandible; under side of scape; hind margin of pronotum at least in the middle (in one paratype over most of pronotum); a spot in upper corner of mesepisternum; sometimes a streak on upper plate of metapleuron; most of the slanting median area of propodeum; entire postscutellum; part or most of scutellum (usually either along hind margin only or forming also spots on the disk); and sometimes traces of an apical band at the sides of tergite 1 (in one paratype a complete narrow apical band and a median dot behind the extensor muscle). Legs somewhat brownish-black; tibial spurs and claws testaceous-brown. Wing mostly hyaline, slightly infuscate in the costal, the apex of the subcostal and most of the radial cells; veins blackish-brown; stigma somewhat paler in the center.

Length (head+thorax+tergites 1+2): 8 mm.; of fore wing, 7.5 mm.

*Male*.—Similar to the female. Eyes larger. Clypeus about as wide as high, more regularly pentagonal, densely covered with silvery pubescence; anterior margin slightly produced and very bluntly



- \* pointed medially; outer orbits (genae) very narrow, about one-fourth the width of the eye in profile; antennal sockets nearer the eyes. Antennae of 13 segments; scape much shorter than in the female; 13th segment about twice as long as wide at base; flagellum russet beneath. Terminalia (fig. 1, F): aedeagus with a heavy, simple shaft, ending in a broadly oval, flat spoon, with rounded edges. Prosternum, under side of fore and mid coxae, and spots on mesosternum and on hind coxae yellow.

Length (h.+th.+t. 1+2): 7.5 mm.; of fore wing, 7.2 mm.

Panama: Barro Colorado Island, Canal Zone, female holotype, male allotype and several paratypes of both sexes (Nathan Banks; J. C. Bradley; and Otis E. Shattuck). Holotype, allotype and paratypes at Mus. Comp. Zool., Cambridge, Mass.; paratypes also at Dept. of Entomology of Cornell University, U. S. National Mus., American Museum of Natural History, and Academy of Natural Sciences of Philadelphia.

In Ducke's key to the Neotropical *Polybia* (1910, Ann. Mus. Nat. Hungarici, VIII, pp. 491-496) *P. barbouri* runs out to couplet 29, which contrasts *P. catillifex* and *P. fastidiosuscula*. It is readily separated from *P. catillifex* Moebius and the related *P. nidulatrix* J. Bequaert by the presence of a fine raised line between genae and occiput, in addition to the very different coloration. From *P. fastidiosuscula* de Saussure it is distinguished by the bare eyes, the much broader first tergite and the color pattern. The bare eyes, presence of a raised line between genae and occiput, and lack of discrete punctures on the thorax differentiate it from *P. nigratella* R. du Buysson (see J. Bequaert, 1943, Jl. New York Ent. Soc., L, for 1942, p. 300). A Central American form of *P. occidentalis* (Olivier) (var. *spilonota* Cameron) is somewhat homeo-chromic with *P. barbouri*, but, like all varieties of *occidentalis*, it is smaller and lacks the ridge of the humeral margin. The lack of a median concavity on the propodeum separates *P. barbouri* from *P. jurinei* de Saussure and *P. signata* Ducke, which are somewhat similar in color pattern.

*P. barbouri* is named for Dr. Thomas Barbour, to whose initiative and perseverance the biological laboratory of Barro Colorado Island in Gatun Lake owes its existence.

A nest from which some of the paratypes were taken and now at Cornell University, was sent to me by Mr. H. Dietrich, together with Dr. J. C. Bradley's field notes. It was placed about 10 feet above the ground in a small tree in the forest. The inmates, it was noted, were "not more than moderately bellicose." The structure is bell-shaped, about 12.5 cm. long and 7 cm. wide, entirely built of paper, and of the type of architecture usual in the genus *Polybia*. When found, it comprised seven horizontal, slightly curved combs, with the convexity downward, where the cells open. The individual cells are about 10 mm. long and 3.5 mm. wide. This nest agrees well with figures published by P. Rau of nests found on Barro Colorado Island and attributed by him to *Polybia signata*, after the late Miss Sandhouse's identification (1933, Jungle Bees and Wasps of Barro Colorado, pp. 73-75, figs. 29-31). There can be little doubt that Rau's observations on these nests and the habits of their inmates refer to my *P. barbouri* and not to the South American *P. signata* Ducke. Rau noted that his wasp stores honey in the nest.

# STUDIES ON THE GASEOUS SECRETION OF TRIBOLIUM CONFUSUM DUVAL

## II. THE ODORIFEROUS GLANDS OF TRIBOLIUM CONFUSUM

LOUIS M. ROTH,

Washington Square College, New York

### INTRODUCTION

It has long been known that *Tribolium confusum* Duval gives off an odoriferous substance. <sup>4</sup>Chittenden (1896) noticed that a few flour beetles were enough to give a "persistent and disagreeable odor to the infested substance." The gas given off by the *Tribolium* adults deleteriously affects the viscous and elastic properties of a dough made from infested flour (Payne, 1925). Park (1934) reported that Dr. John Stanley believes "... the gas along with certain fluids found in *Tribolium* may be irritating to man resulting particularly in gastric disorders." However, from experiments on rats and man, there is no evidence that injury would result from the ingestion of confused flour beetles as they may accidentally occur in cooked cereals (Mills and Pepper, 1939). Abnormal adults have been obtained by subjecting immature stages of *Tribolium* to the vapors of the secretion (Chapman, 1926). Roth and Howland (1941) isolated the substance and also obtained interesting monstrosities by subjecting different stages to both the fumes and crystals of the secretion. However, although many interesting facts have been established concerning this substance, the organs which produce the material have never been described. <sup>1</sup>Good (1936) states that the scent glands of both *Tribolium confusum* and *T. castaneum* are well developed and are possessed by the adults but not by the larvae.

It is the purpose of this paper to describe the development and structure of these odoriferous glands from a study of them in the living condition and from fixed preparations, and to report other interesting data which have been noted during this investigation.

The author wishes to take this opportunity to thank Dr. Ruth B. Howland, under whose supervision this work has been carried out, and Dr. Roberts Rugh for his generous aid in photographing the material.

### MATERIALS AND METHODS

The insects were reared in the manner described by Roth and Howland (1941). Eggs were sifted out of a medium made up of whole wheat flour (Wheatworth) and powdered unirradiated yeast<sup>1</sup> which had been previously sifted through a number 3 bolting cloth and inoculated with about 50 adults. Two hundred eggs per 80 gms. of wholewheat flour per finger bowl were reared at 27° C. The various stages used were sifted from the flour when needed.

<sup>1</sup>The author wishes to thank the Fleischmann Laboratory (Bronx) for a supply of unirradiated yeast.

The glands were studied in the living condition by vital staining with a very dilute solution of methylene blue. Serial slides were also made of pupae and adults of various ages. These were fixed in Dietrich's solution,<sup>2</sup> Carnoy-Lebrun,<sup>3</sup> and alcoholic Bouin's. Dietrich's was found most satisfactory. Sections were cut at 7 and 8  $\mu$ . and stained with Delafield's haematoxylin and eosin.

Since varied and numerous techniques have been employed throughout this investigation, it is felt that for the sake of clarity these should be described in the section of the paper with which each is concerned.

## DESCRIPTION

### TIME OF APPEARANCE OF THE SECRETION

The odoriferous substance given off by *Tribolium confusum* Duval is an oxidizing compound and by merely holding a beetle on acidulated KI starch paper a characteristic blue black color (starch test) appears. This is a result of the iodine, released from the KI, combining with the starch.<sup>4</sup> This simple test provides an excellent method for determining when the secretion first appears. However, before this test could be shown to be valid it was necessary to prove that only the yellow oil taken from the reservoirs will give a positive iodine reaction. This was done in the following manner. Some permoplast was placed at the bottom of a Syracuse dish and a small depression, large enough to hold the head and thorax of the adult beetle, was made. The beetle was then inactivated on ice and its head and thorax were placed in the depression and covered by the permoplast, thus holding the animal somewhat solidly. The elytra and wings were then pushed forward toward the head and embedded firmly in the permoplast, exposing the abdominal reservoirs through the dorsal wall of the animal. Micropipettes were then drawn from .22 mm. pyrex tubing and these were attached to an injection circuit similar to that used on a Chambers micromanipulator. The point of the micropipette was inserted into various parts of the body of the beetle. Generally suction was not necessary since capillary action caused the body fluids to flow up into the pipette. The liquid was then either forced out of the pipette by pressure on the syringe, or the point of the pipette was broken and crushed, on strips of acidulated KI starch paper, to see if there was any discoloration. All of the body fluids taken from parts other than the reservoirs gave a negative reaction. These fluids were usually colorless except when some organic tissue was sucked up into the pipette, making it appear grayish. Only the yellow fluid taken from the reservoirs themselves gave a positive reaction.

Larvae of all instars, prepupae, pupae, and adults were irritated

<sup>2</sup>The formula for Dietrich's solution is:

Distilled water.....	60 cc.
95% alcohol.....	30 cc.
40% formalin.....	10 cc.
Glacial acetic acid.....	2 cc.

<sup>3</sup>Carnoy-Lebrun consists of equal volumes of absolute alcohol, glacial acetic acid, and chloroform, saturated with mercuric chloride.

<sup>4</sup>This test was originally suggested by Prof. K. C. Blanchard, of Washington Square College, as a test for an oxidizing substance.

(by stroking with a pair of forceps or needle) or crushed on acidulated KI starch paper (see fig. 14, Pl. II) to determine at what developmental stage the secretion appears. Pupae were separated into three distinct stages according to morphological changes in pigmentation:

Stage I. Pupa completely white or light tan. Eye pigmentation ranging from very light to dark. Mouthparts and legs not pigmented. (1 to 7 days after pupation at 27° C.)

Stage II. Eyes and tips of mandibles darkly pigmented. Tarsal claws brown and easily distinguishable. Antennae and legs not yet pigmented. (About 8 days after pupation at 27° C.)

Stage III. Eyes and tips of mandibles black. Genae dark brown. Antennae, tibiae and tarsi of legs light or dark brown. Tarsal claws moving freely within the pupal skin. (About 9 days after pupation at 27° C.) The entire pupal period lasts approximately 9 days at this temperature with humidity uncontrolled.

The sexes were separated in the pupal stage by the characteristic difference in the genital segment. The animals were considered emerged when the head, thorax, and prothoracic legs were out of the pupal skin. All tested animals had been raised at 27° C. until shortly before emergence as adults. These adults were isolated immediately after emergence, placed in Syracuse dishes (with filter paper on the bottom to give them a foothold) and then were tested, at room temperature, on the acidulated KI starch paper at definite intervals. Once tested, the animals were discarded. If no reaction was obtained by irritating the adults, they were then crushed on the test paper for it was found that occasionally the beetles may not give off the secretion voluntarily even though their sacs contain some of the substance. The results are shown in Table I.

From Table I it is possible to conclude the following:

1. There is no detectable secretion in larvae of all instars and in prepupae.

2. The substance appears at the same time in both male and female adults.

3. The secretion may first appear in very late pupae, or those which are just ready to emerge. At this time the positive reaction comes from the thorax only. However, since so few of these individuals give the positive test we may say that in general pupae do not possess any secretion.

4. Newly emerged adults possess the secretion in the thorax only. At this time the substance may be given off voluntarily if the beetle is disturbed. The starch reaction is generally much weaker than that of older beetles. However, a few individuals give a negative reaction to the test at emergence.

5. The secretion may be present in the abdomen one hour after emergence. It is definitely present in this region two hours after emergence but the reaction from the abdomen is much weaker than that obtained from the thorax of the same animal.

- ✓ 6. There is a decided increase in the amount of secretion with increase in age. This is shown by the increase in the intensity of reaction with KI starch paper and also by dissecting beetles of different ages and observing the volume of fluid in the sacs.

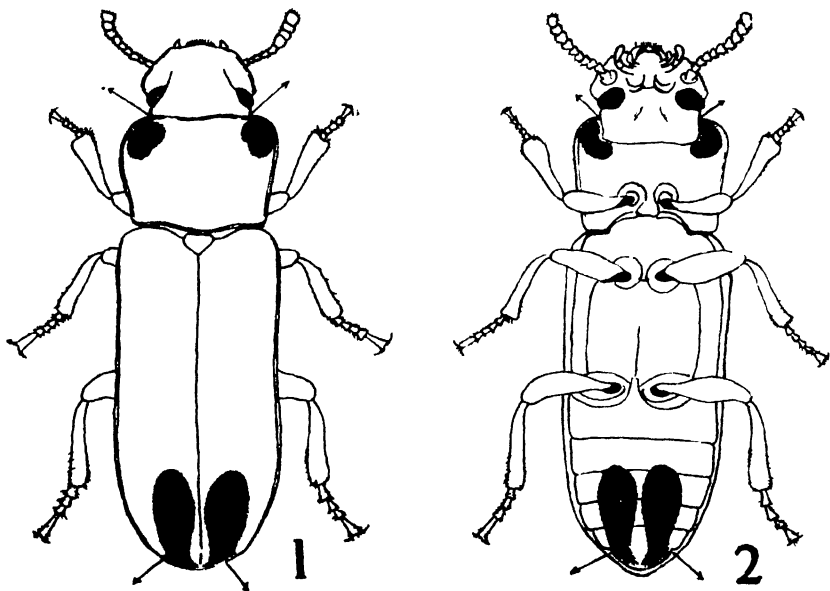
TABLE I

RESULTS OF TESTING DIFFERENT STAGES OF *TRIBOLIUM* FOR THE PRESENCE OF THE SECRETION (AT ROOM TEMPERATURE)

Developmental Stage	Reaction + or -	Number of Animals Tested	Remarks
Larvae (all instars)	—	50	All of the larvae were crushed on acidulated KI starch paper.
Prepupae	—	25	Same as for larvae.
Pupae (males)			
Stage I	—	50	All of the pupae were crushed on the test paper. In the 6 individuals of Stage III, the + reaction came from the thorax only and was not given off voluntarily. These beetles were probably just ready to emerge.
Stage II	—	50	
Stage III	—	55	
	+	6	
Pupae (females)			
Stage I	—	50	Same as for male pupae.
Stage II	—	50	
Stage III	—	60	
	+	14	
Adults (males)			
Time after emergence.			
0 min.	—	5	The + test was given by beetles which had just emerged or were only partly out of their pupal skins. The reaction was obtained from the thoracic region only and the animals gave off the gas when stroked with a brush. The iodine reaction was much weaker than that obtained from older beetles.
	+	42	
30 min.	+	21	Reaction was obtained from thoracic glands only.
60 min.	+	29	19 individuals gave a thoracic reaction only. 10 animals gave a + test from both thorax and abdomen, but the abdominal reaction was much weaker than the thoracic one of the same animal.
90 min.	+	21	5 animals gave a thoracic reaction only, while the other 16 gave + tests from both thorax and abdomen.
120 min.	+	35	All animals gave a + reaction from both the thorax and abdomen but the abdominal discoloration was still, generally, weaker than the thoracic one. After two hours the reaction obtained from both the thorax and abdomen increased in intensity with increase in age of the beetle.
Adults (females)			
Time after emergence			
0 min.	—	4	Same as for male adults.
	+	74	
30 min.	+	12	Reaction from the thorax only.
60 min.	+	39	23 gave + tests from the thorax only. 11 gave reactions from both the thorax and abdomen.
90 min.	+	17	8 gave + tests from both thorax and abdomen. 9 gave tests from thorax only.
120 min.	+	27	Same as for males.

## EFFECT OF INANITION ON SECRETORY ACTIVITY

Starvation apparently has no effect on the initial production of the secretion. Some adults which had been isolated from food on emergence, showed full turgid abdominal and thoracic reservoirs after eight days of starvation (Pl. II, fig. 12). However, others show a quantity of secretion in the thoracic sacs only. After thirteen days of starvation, individuals generally show little secretion in their sacs (Pl. II, fig. 13) and generally less than individuals starved for eight days. This may indicate that if any secretion is given off within this period the beetle cannot manufacture new oil unless provided with food. Since starved adults can produce the secretion it is apparent that this substance is originally manufactured from the food materials taken in during the larval period and stored in some form until converted into the odoriferous substance by the secretory cells of the adult.



Text Figure 1, dorsal view; 2, ventral view.

Drawings of adult *Tribolium* showing the position of the turgid thoracic and abdominal reservoirs (stippled areas in the thorax and abdomen). The arrows indicate the regions from which the substance is emitted.

## THE ODORIFEROUS GLANDS AND ACCESSORY STRUCTURES

The odoriferous glands of both male and female adults are equally well developed and consist of two main structures, namely, the glandular secreting cells themselves which lead (by means of small ducts) into a large chitinous reservoir or sac for storing the secretion. The adults possess two pairs of functional glands, one pair prothoracic, the other abdominal. There are four openings, one for each reservoir (Text Figs. 1 and 2). The various parts of the system will now be described separately.

*The Abdominal Reservoirs.*—When the elytra and wings of an adult, whose sacs are full of secretion, are removed or pushed aside, the reservoirs in the abdomen can be seen through the tergum since the dorsal cuticula is not melanized. These large sacs are filled with a yellowish fluid. The amount of fluid in the sacs, and therefore the volume of the reservoir, varies with the age of the individual. The older the beetle generally the more oil and therefore the larger the reservoir. The sacs appear as two large yellowish elliptical bodies, lying on either side of the digestive tract, and when full usually take up the last three abdominal segments. The size and shape of the sac may be somewhat obscured by fat bodies or by the intestine and reproductive tract which run between them.

The reservoirs can be removed from the body by holding the anterior part of the abdomen with a needle and pulling the last abdominal segment away with another needle. In this way the reproductive and digestive tracts and the odoriferous glands are all freed from the rest of the body but remain attached to the last abdominal sclerite. When freed in this manner, the reservoirs expand and become somewhat pear-shaped, as they are no longer under the influence of body pressure (Pl. I, fig. 2).

Serial sections show that the sac is formed by an invagination of part of the insect cuticle. This membranous wall is not as thick as the cuticular wall surrounding the insect's body (Text Fig. 3). As the reservoirs are insoluble in concentrated  $H_2SO_4$ , they should be a continuation of either the epi- or exocuticle. The endocuticle is soluble in concentrated acids, and the unknown chemical substance which has the power to resist solubility in concentrated  $H_2SO_4$  is present only in the epicuticle while in the exocuticle it is incorporated with the chitin and protein (Wigglesworth, 1939). If the entire sacs are placed in this medium, the acid changes the yellow fluid to a deep red which may appear black because the mass is opaque (Pl. I, fig. 4). When placed in KOH or NaOH, the yellow contents of the sac become black. The reservoirs are not soluble in hot KOH (caustic potash) or hot 50 per cent NaOH. Therefore the reservoir is not part of the epicuticle since cuticulin which makes up the cuticle is soluble in hot alkalis. The epicuticle contains neither chitin nor protein (Wigglesworth, 1939). This leaves only the exocuticle as ~~the~~ part of the cuticle which forms the reservoir.

To determine if the reservoirs contain chitin, the abdominal sacs were subjected to the tests for chitin by the technique described by Campbell (1929). Turgid abdominal reservoirs were dissected away and left attached to their last abdominal sclerites (Pl. I, fig. 2). These were placed in 3 cc. of saturated KOH, in a shell vial ( $\frac{3}{4}$ " x 3") and heated slowly in a paraffin bath to 160°C. and kept at that temperature for 15 minutes. The Bunsen valve described by Campbell was used. The vial was allowed to cool to room temperature and the contents were poured into a Syracuse dish. The sacs had not dissolved and were still attached to the last abdominal sclerite which had become colorless. The yellow contents of the sac had become black, or in some cases gray if some of the material had dissolved out. The sacs were then passed from higher to lower percentages of alcohols and finally washed

in water. During this process much more of the black material had dissolved in the alcohol, although some remained. The sacs sometimes became brownish.

When a drop of 3 per cent acetic acid was placed on these reservoirs and the abdominal sclerites, the sclerites dissolved almost immediately, leaving the sacs intact. On adding a drop of 1 per cent  $H_2SO_4$ , a white precipitate, chitosan sulphate, appeared where the sclerite had gone into solution. Thus the abdominal sclerite gave the test for chitin while the reservoirs did not. When a drop of .2 per cent iodine in KI solution was added to other pairs of reservoirs, the last abdominal segment became brown while the sacs were generally unaffected. On adding a drop of 1 per cent  $H_2SO_4$  the brown segment became a deep reddish violet, the sacs still remaining unaffected. Occasionally a weak positive test was obtained from the sacs. Repeated tests gave the same results.

It was thought that possibly the contents of the sacs reacted with the membranous reservoirs to form some substance which would not give or interfered with the typical test for chitin. Therefore the abdominal sacs were dissected out, punctured, and placed in ether in order to dissolve away their contents. This could in no way interfere with the test, as chitin is insoluble in ether (Wigglesworth, 1939). The ether treated sacs were then subjected to the chitin tests. After the alkali treatment, the sacs were partly dissolved in 3 per cent acetic acid while their abdominal sclerites dissolved completely, and the characteristic precipitate of chitosan sulphate was obtained on adding a drop of 1 per cent  $H_2SO_4$ . However, the sacs gave an excellent positive test with the iodine-dilute acid, becoming a deep reddish violet in a drop of that solution.

The abdominal reservoirs of Stage III pupae (those shortly to emerge) and newly emerged adults were also subjected to the chitin tests. In these animals, the sacs are already present but are collapsed and wrinkled and as yet contain no fluid. Therefore the chitin test can not be influenced by the secretion. These reservoirs gave clear cut positive tests for chitin. Thus it is very probable that the failure to get a characteristic test for chitin when the entire turgid sacs plus their contents are treated is due to the interference of the secretion itself. From these various tests we may conclude that the membranous reservoirs are probably continuations of the exocuticle and are chitinous. Wigglesworth (1934), citing Weber, states that the odoriferous glands are nearly always lined with a delicate membrane continuous with the epicuticle. If we consider the reservoir as the lining of the odoriferous glands in *Tribolium* then we have an exception to the above observation.

Measurements were taken of full turgid reservoirs which were dissected away in distilled water. Only animals with turgid reservoirs were measured, these individuals being taken about two months after emergence (at 27° C.). The length of the sac was measured from the projections of the lateral margins of the last abdominal sclerite (Pl. I, fig. 3, LP) (ventral side up) to the apex of the reservoir. The width of the reservoir was taken at its widest point. The average length of turgid abdominal reservoirs of 15 individuals was 675  $\mu$ . with a width of 329  $\mu$ .



It was found that the entire exoskeleton of the adult is resistant to the KOH treatment. Since the cuticula becomes colorless and transparent after the strong alkali treatment, and the sacs become black, an excellent method is present for demonstrating these reservoirs in their normal position within the body. Treating the animals in a 50-80 per cent KOH solution heated to 140°-150° C. for one half hour or more was better than heating to 160° C. in a saturated solution since there was less disruption of the sacs. Removing the elytra and wings and puncturing the dorsal cuticula also helped, for it gave the body tissues an opportunity to dissolve out without stretching and distorting the animal (Pl. II, figs. 9-13, 15, 16). Actually within the body, the sacs are longer and slightly narrower. Animals which were cleared in hot KOH leaving the reservoirs clearly standing out showed that the turgid sacs may extend farther than the upper margin of the last three

#### EXPLANATION OF PLATE I

FIG. 1. The abdominal reservoirs (R) of an adult four days after emergence. The sacs are collapsed due to the fact that they are only partly filled with the secretion (S). The digestive and reproductive tracts have been dissected away.

FIG. 2. The abdominal reservoirs of an adult about two weeks after emergence, showing the turgid sacs full of secretion.

FIG. 3. Turgid abdominal reservoirs showing the effect of puncturing the left sac. Some of the secretion has flowed out and the membranous wall has collapsed.

FIG. 4. Turgid abdominal reservoirs after concentrated  $H_2SO_4$  has been drawn under the cover slip. The acid has already reached the right sac causing almost all of the yellow contents to turn red. A small area is still unaffected. The membranous wall of the reservoir does not dissolve. The left sac is still yellow since it has not yet been reached by the acid.

FIG. 5. The abdominal reservoirs of *Gnathoceros cornutus*. The secretion is found in the rounded apical region of the sac, and the reservoirs, even though not completely filled with fluid, are not collapsed. The digestive and reproductive tracts have been dissected away.

FIG. 6. The abdominal reservoirs of *Gnathoceros* (under compression of a cover slip) showing the striated structure of the sacs, and the long thin crystals (C) which may be present with or without the yellow secretion.

FIG. 7. The eversible repugnatorial glands (G) of *Tenebrio molitor* shown being extruded (by pressure of a pin (PN) on the abdominal sclerites) over the last abdominal sclerite. The secretion, which is exposed to the air, gives the gland the glossy, fleshy appearance. The small black specks are the solid material (SO) which cling to the sacs when everted.

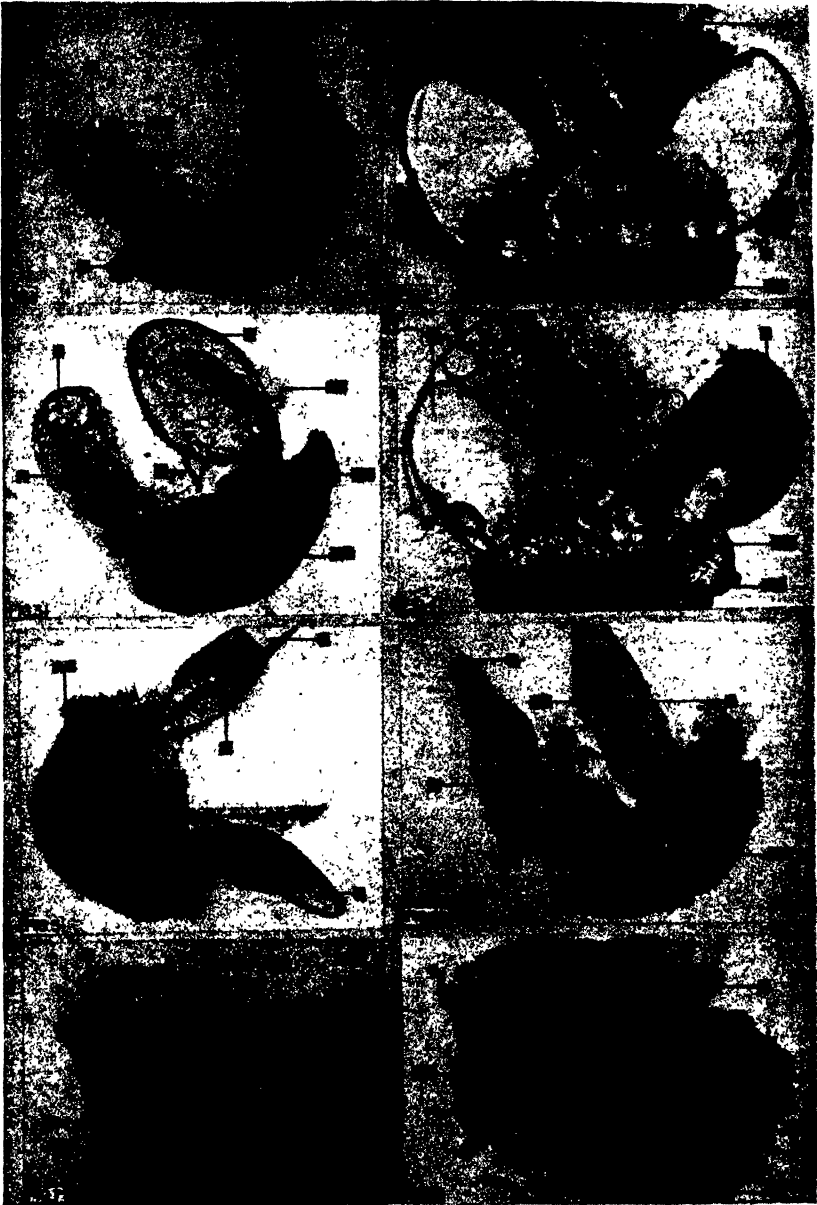
FIG. 8. One of the eversible glands of *Tenebrio*, showing the secreting aggregates of cells (LS) and the somewhat round shape of the retracted gland. The dark material is the solid.

#### EXPLANATION OF ABBREVIATIONS

AS—last abdominal sclerite  
B—air bubble  
C—crystals  
G—everted gland  
I—intestine  
LS—secreting cells  
LP—lateral projection of last abdominal sclerite

P—penis  
PN—pin pressing down on abdominal sclerite  
R—reservoir  
RT—reproductive tract  
S—secretion  
SO—solid matter in sac  
T—tracheae

For figs 1-6 and 8, all specimens were dissected out and photographed in distilled water. Figs. 1-4, actual width of last abdominal sclerite, 700 mu.



## EXPLANATION OF PLATE II

FIG. 9. Newly emerged adult. Although the sacs are already formed, (the abdominal ones (AR) can be faintly seen) there is no blackening because the secretion has not yet been formed. The thoracic sacs give a positive reaction for the presence of the secretion (with KI starch paper) at emergence, but no doubt the amount is so small that it is dissolved out during the alkali treatment.

FIG. 10. An adult ten days after emergence (fed on wholewheat flour at 27° C.), showing the thoracic sacs already turgid with secretion while the abdominal ones have not yet expanded to their fullest capacity.

FIG. 11. An adult fifteen days after emergence (fed on wholewheat flour at 27° C.), showing the expanded reservoirs. The left abdominal sac already extends to the upper margin of the third abdominal sclerite. The right sac did not contain as much secretion and therefore is smaller than the left one.

FIG. 12. An adult that has been starved for eight days, showing turgid sacs, indicating that food is unnecessary, in the adult stage, for the initial production of the secretion.

FIG. 13. An adult starved for thirteen days, showing the comparatively small amount of secretion in the sacs, as compared with the eight-day starved adult.

FIG. 14. A newly emerged adult (still white and soft) which has been disturbed on acidulated KI starch paper. The secretion is given off from the thoracic sacs only and the vapors discolor the paper around the head. (The darkened areas along the abdomen are due to the shadow of the beetle. The light was coming from the right.)

FIG. 15. Head and thorax (ventral view) of an adult about two months after emergence, showing the huge size which the thoracic reservoirs may attain.

FIG. 16. The abdomen of an adult about two months after emergence, showing the large reservoirs which reach more than half way across the second abdominal sclerite and take up almost the entire width of the last three abdominal segments.

FIG. 17. Frontal section through a newly emerged adult showing the small ducts (DU) leading to the opening in the rounded front angle of the prothorax. The sacs are already slightly expanded and a lumen is present indicating the presence of secretion (dissolved away). Secretory cells are seen, and note that the opening is at about the same level as the digestive tract. (Fixed in Dietrich's solution, stained with Delafield's Haematoxylin and Eosin, and cut at 8  $\mu$ .)

FIG. 18. Frontal section through the abdominal region of the same animal as in fig. 17. The reservoirs are collapsed and the absence of a lumen probably indicates the absence of secretion at this time. Individual secreting cells may be seen closely adpressed to the sacs.

## EXPLANATION OF ABBREVIATIONS

AR—abdominal reservoir	O—oenocytes
D—discoloration of starch paper due to secretion	P—prothorax
DU—duct	PL—prothoracic leg
H—head	SC—individual secreting cells
I—digestive tract	TL—lumen in the thoracic reservoir
KI—acidulated KI starch paper	TR—thoracic reservoir
LS—secreting cells	1, 2, 3, 4, 5—first, second, third, fourth, and fifth abdominal sclerites respectively.
ML—metathoracic leg	

For figures 9-13 and 15-16 the specimens were treated with 80 per cent KOH at 140° C. for about one-half hour. Actual size of adult, 4 mm. long.



abdominal sclerites and may measure 825  $\mu$ . in length. Measurements were still taken from the projections of the lateral margins even though it was found that the sac may sometimes extend slightly below this point (Pl. II, fig. 13, AR). The length of the abdominal sacs of individuals prepared in this manner averaged 710  $\mu$ . with a width of about 300  $\mu$ . From Pl. II, fig. 16, one can see that turgid sacs may take up more than half the width and extend half way or more down the length of the abdomen. The sacs follow the contour of the body.

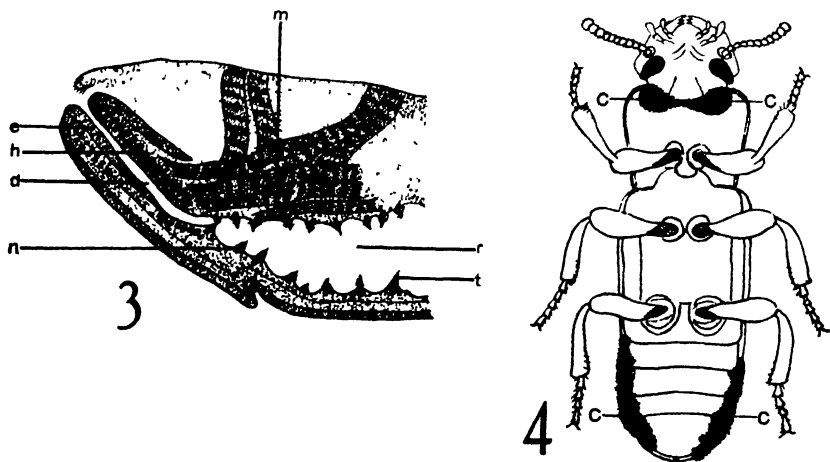
In newly emerged adults the reservoirs extend over the last two abdominal sclerites but are collapsed, wrinkled, and contain no secretion (Pl. II, figs. 9, 18, AR). However, the sacs are fully formed long before they become completely expanded with secretion. Fig. 1 (Pl. I) shows the abdominal reservoirs of an adult four days after emergence. They are fully formed, but collapsed and only partly filled with secretion (s). In some individuals the abdominal reservoirs may be practically full in 7-10 days after emergence and are generally full in two or three weeks (Pl. I, fig. 2; Pl. II, fig. 11). In general both sacs contain about the same amount of secretion. However, some individuals are found in which one sac contains more fluid than the other (Pl. II, fig. 11).

The reservoirs collapse very easily and if punctured (Pl. I, fig. 3) liberate the oily fluid as large globules which generally float to the surface of the medium (distilled water) and burst into many small oily droplets. The fluid is very adhesive and will cling to a dissecting needle when removed from the sac. Under higher magnification, the yellowish oil can generally be seen as large and small globules which move about within the sac. The sac itself is cellophane-like without any apparent visible cellular structure. However, if vitally stained with methylene blue many small hypodermal nuclei appear scattered over the surface. Also scattered over the surface are many small wrinkles (Text Fig. 6, w), and these are arranged in definite groups or patterns, each group radiating from a single point. The nuclei and wrinkles probably denote the places where the membrane is thrown into bristles on the inner surface of the sac. (This will be described later under development of the reservoirs.)

Sections through the abdomens of adults two to three weeks after emergence show that the abdominal reservoirs possess a closing mechanism. The reservoir narrows down to a long duct (Text Fig. 3, d) which is lined by a continuation of the amber colored epicuticle. The upper surface of the duct is thickened, has a row or rows of hypodermal nuclei (Text Fig. 3, h) and has a group of muscles running into it (Text Fig. 3, m). When these muscles are relaxed, the opening to the reservoir is closed. When contracted, the muscles lift the upper surface of the duct away from the lower one, thus opening up the reservoir and allowing the fluid to vaporize and escape. These muscles follow and lie close to the surface of the reservoir (Text Fig. 3) and upon contraction would not only open the duct but would even depress the sac thus aiding in forcing out the secretion. The closing mechanism is so efficient that artificial pressure applied with a needle and strong enough to break the dorsal abdominal wall may not force out the secretion from the abdominal reservoirs.

*The Thoracic Reservoirs.*—The reservoirs of the thoracic glands are more difficult to observe because both the dorsal and ventral surfaces of the thorax are melanized. When full of secretion they may be as large as turgid abdominal sacs. Using a binocular microscope with dark field and transmitted light, the thoracic sacs may be seen from the ventral surface in the living animal as half-moon shaped structures slightly darker than the chitin. With reflected light the sacs appear somewhat transparent through the thoracic cuticle. This pertains to animals whose reservoirs are full of secretion.

By removing the head and abdomen, and then picking away the thoracic cuticle with dissecting needles, the reservoir and glandular cells may be freed. The thoracic reservoirs, like the abdominal pair,



Text Figure 3. A semi-schematic drawing of a longitudinal section through the abdomen of an adult about two weeks after emergence, showing the closing mechanism of the abdominal reservoirs. d—duct, e—epicuticle, h—hypodermal cells, m—muscles, n—hypodermal nuclei, r—reservoir, t—bristle. Outlined with the aid of a camera lucida. Fixed in Dietrich's solution and stained with haematoxylin. Actual height of abdomen, 115  $\mu$ .

Text Figure 4. Diagram of an adult which has been inactivated on ice, showing the general regions where the secretion crystallizes out on the body. The stippled areas (C) on the thorax and abdomen indicate clumps of crystals.

possess numerous hypodermal nuclei and wrinkles over their surfaces. The sacs are wide near their point of attachment (dorsal) and taper down to a point at their apex. They follow the contour of the thorax and run dorso-ventrally. Adults about two months after emergence show turgid sacs which may extend more than half way down the prothorax and their apices may cross along the mid-ventral line (Pl. II, fig. 15). The thoracic sacs in general seem to fill up before the abdominal ones (Pl. II, fig. 10). However, the abdominal sacs fill up shortly afterwards and generally have a greater volume than the thoracic reservoirs.

It was difficult to get good sections through the thoracic region of older beetles as both the dorsal and ventral cuticula are heavily sclerotized. In the abdominal region, the tergum is not extensively sclerotized so that the animals may be sectioned from the dorsal to ventral surface. Thus any tearing due to the hardness of the ventral abdominal sclerites will not necessarily injure the tissue. It appears that a closing mechanism, like that found for the abdominal reservoirs, is not present for the thoracic sacs. In fact, the duct leading to the outside is so short (Pl. II, fig. 17, DU) that it is almost impossible to have a muscular closing mechanism such as that found in the abdomen. Sections show that many muscles are present in the thorax around and in the reservoir region and possibly contraction of these muscles helps force the secretion out through the openings. What is difficult to explain is the retention of the secretion within the sac even though the exit is continually open. However, from a study of sections, the opening is seen to be very minute and in life it is possible that this opening is even smaller, so that little secretion escapes except under great internal pressure.

*The Openings to the Reservoirs.*—When an adult *Tribolium* is placed in acidified KI starch solution, the beetle gives off the secretion which in turn discolors the solution. Under the binocular microscope, the secretion from the abdominal reservoirs can be seen flowing in two streams through two openings in the last abdominal pleurite, one on either side of the anal opening. These are at points on the last abdominal sclerite where the lateral margins project conspicuously (Pl. I, fig. 3, LP) and where there is an indentation immediately posterior to these projections (Text Fig. 2, arrows in abdominal region). This can be more clearly seen by substituting  $H_2SO_4$  alone for the starch solution. This acid is more viscous than the other medium and as the beetle gives off the secretion, the solution becomes brick red immediately around the openings of the reservoirs.

The opening of the thoracic sac is found at the apex and rounded front angle of the prothorax, close to the head at about the level of the intestine (Pl. II, fig. 17, DU). There are two such openings, one for each sac, in each corner of the prothorax (Text Figs. 1 and 2, arrows in the thoracic region).

*Development of the Reservoirs.*—In the thoracic reservoir region of newly formed pupae, many hypodermal cells are seen, the cytoplasm of which forms long thin filaments. The cuticle is still entire, that is, the opening to the outside has not yet formed. Three to six days after pupation, the sac is already well developed and the opening to the outside is present. A small duct lined by a thick layer of hypodermal cells leads to the opening. The hypodermal cells have greatly proliferated in this region and these are almost entirely nuclear material with very little if any cytoplasm. Many of these nuclei migrate in with the reservoir membrane and these eventually lie at the points where the bristles develop. At this time small projections from the membrane indicate that these bristles are already forming. Immature bristles generally have many lightly staining lateral projections which seem to disappear from the sacs of older beetles (Text Fig. 3, t). The

nuclei at the base of the bristles also become much smaller as the sac and bristles develop. It is possible that these hypodermal cells form the bristles and as they develop they tend to push in the sac membrane thus producing the characteristic wrinkles which are present all over the surface of the reservoirs. The function of these bristles is not known but it is possible that they serve to increase the internal surface area of the sac or to check the flow of oil along the walls. In newly emerged adults the thoracic reservoir duct is lined by the amber colored epicuticle.

In sections through the reservoirs of pupae it is seen that the sacs are filled with a more or less lightly staining substance. This substance can be traced out of the openings of the sac and is found to be identical with the lightly staining material present between the pupa proper and the outer puparial membrane which is eventually shed when the adult beetle emerges. This substance may possibly be a liquid in life. In sections through the reservoirs of adult beetles the material in the sacs is dissolved out so that the reservoir is represented by the membrane which surrounds an empty non-staining area (Text Fig. 3, r).

The abdominal reservoirs may be detected at the same time as the thoracic ones and they differ in having a much longer duct leading to the outside (Text Fig. 3, d). The development is the same with a great proliferation of hypodermal cells migrating in with the reservoir membrane, and the formation of bristles.

*The Glandular Secreting Cells.*—There are two types of secreting cells:

1. Individual or paired cells which lie closely adpressed over the surface of the reservoir. In life, these are generally round but may be flattened on the side close to the sac. These are small cells with minute granules or larger cells filled with oil-like globules. Nuclei are observed with difficulty in the living condition. A small twisted tube can be seen in these cells, and it appears as if both ends of this cuticular tube end in the cytoplasm of the cell itself (Text Fig. 11, c). Actually, one end of the tube leads directly into the reservoir at the point of attachment of the cell. This can be clearly seen by dissolving away the cells with KOH or  $H_2SO_4$ , leaving only these tubes and the sacs (Text Fig. 12). At the free end of the tube (the portion lying in the cytoplasm of the cell) there is a slight constriction (Text Fig. 12, cn) and the canal then leads into a slightly dilated terminal portion. The paired secreting cells are actually two fused individual secreting cells (Text Fig. 11). Their cell boundaries may be visible in the living condition. These individual and paired cells are found over the surface of the abdominal sacs but are generally lacking in the apical region of the reservoir and apparently are not present on the thoracic sacs.

Whole abdominal glands were dissected out, at different periods after emergence, in distilled water, and vitally stained with methylene blue. In this way the cell outlines could be easily seen and measured. Measurements of individual secreting cells from animals ranging from 42–150 hours after emergence (a period when secretion is actively being manufactured) showed little difference in cell size. They averaged 33.5  $\mu$ . in diameter. Paired secreting cells averaged 49.1  $\mu$ . long and 33  $\mu$ . wide. During most of this period, these cells were



filled with small granules which obliterated all cell structures but the cuticular tube. In individual secreting cells of animals 150 hours after emergence, small clear areas were noted in the cytoplasm. These small areas probably coalesce, for older individual secreting cells may be seen which generally possess one huge vacuole which occupies almost the entire cell leaving only a small margin of cytoplasm. In many cases, very light radiating fibrillae converge toward the center of this vesicle. Sections through these cells in newly emerged adults show that the darkly staining cuticular tube rests in a clear cytoplasmic area. This clear region persists in the cells of older beetles (Text Fig. 11, ca).

2. The second type of cell is much more complex than the first. These occur in lobulated aggregates, each cell with its nucleus, granular cytoplasm, a large clear vacuolar area which will be called the primary vesicle (Text Fig. 5, p<sup>1</sup>), and a smaller vacuolar area which will be

#### EXPLANATION OF TEXT FIGURES 5-13

Text Figure 5. A semi-schematic drawing of an aggregate of secretory cells showing the usual arrangement of the various structures. Actual length of lobe, 170 mu.

Text Figure 6. The tubes from an aggregate of cells which remain after treatment with KOH. The differentiation of the tube is clearly seen, and the canals run into the reservoir. Length of canal, 250 mu.

Text Figure 7. Section through a part of an aggregate of cells in the thoracic region in an early Stage I pupa, showing the groups of hypodermal cells with large nuclei and darkly staining cytoplasm. The canal containing the nucleus leads under the group of cells. Length of part of lobe, 49.5 mu.

Text Figure 8. An individual cell from an aggregate in the thoracic region of a Stage II pupa, showing the smaller nucleus, the secondary vesicle, and the hook resting in the lighter staining cytoplasm which represents the forming primary vesicle. Diameter of cell, 23.1 mu.

Text Figure 9. Section through a part of an aggregate of cells in the abdominal region of an adult three weeks after emergence, showing the difference in staining reaction of the bulb and hook. Width of cell, 33 mu.

Text Figure 10. A tube in the process of formation from the thoracic region of a Stage II pupa. The canal is already formed and leads into the sac. The nucleus is still quite large and causes the canal to bulge. The bulb has already formed and rests in the secondary vesicle. Length of canal, 56 mu.

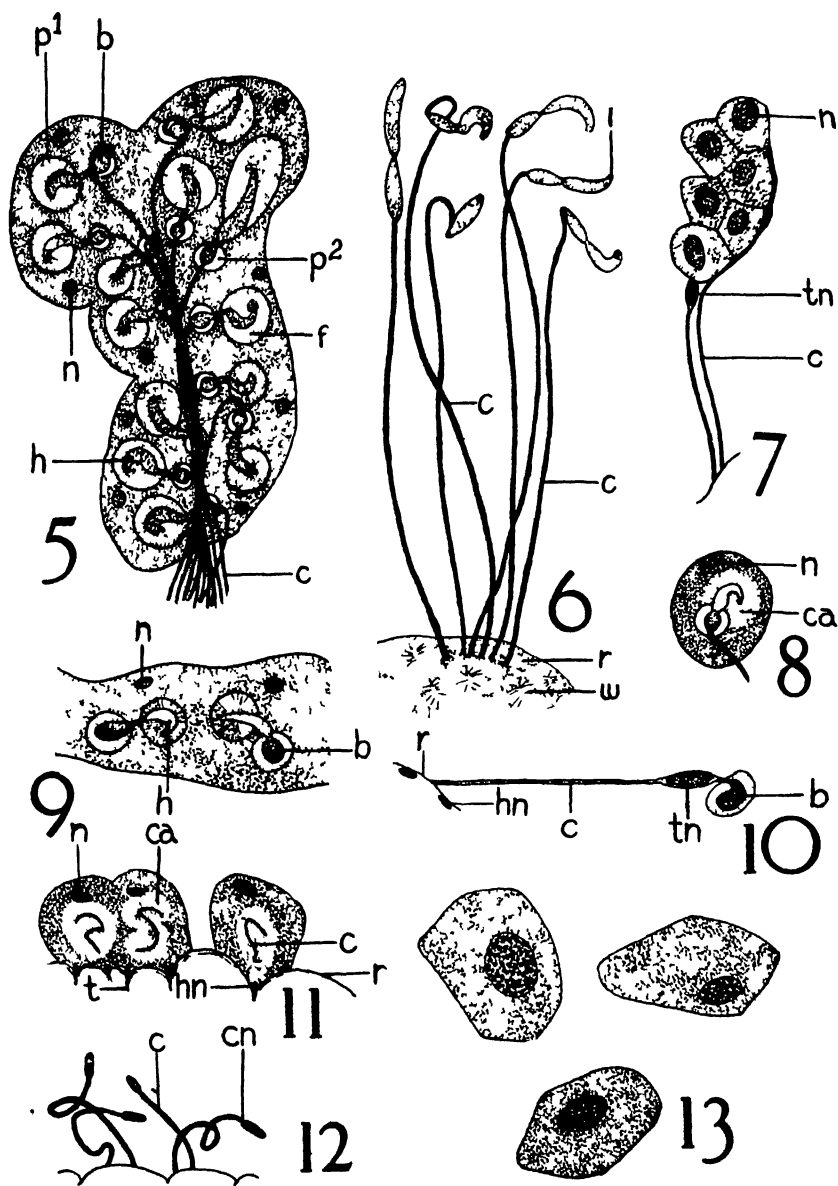
Text Figure 11. Section through an individual and paired secreting cell from the abdomen of an adult three weeks after emergence. The cells are closely adpressed to the wall of the reservoir. Size of single cell, 33 mu.

Text Figure 12. The tubes from individual and paired secreting cells which remain after KOH treatment. Length of canal, 16.5 mu.

Text Figure 13. Oenocytes of an adult three weeks after emergence, showing the darkly staining nuclei and the general shape of the cell. Size of large oenocyte, 33 mu.

#### EXPLANATION OF ABBREVIATIONS

b—bulb	l—lumen (?)
c—canal	n—nucleus
ca—clear area	p <sup>1</sup> —primary vesicle
cn—constriction	p <sup>2</sup> —secondary vesicle
f—radiating filaments	r—reservoir
h—hook	t—bristle
hn—hypodermal nuclei	tn—tube forming nucleus
w—wrinkles on surface of reservoir	



TEXT FIGURES 5-13

Figures 7-11 and 13 were drawn from material fixed in Dietrich's solution and stained with Delafield's haematoxylin and eosin. All drawings were outlined with the aid of a camera lucida.

designated as the secondary vesicle (Text Fig. 5, p<sup>2</sup>). The primary vesicle generally contains fine radiating fibrillae converging toward its center (Text Fig. 5, f). No fibrillae are noticeable in the secondary vesicle. A long thin chitinous tube runs into each cell where it is differentiated into three main structures: (a) a curved end, called the hook (Text Fig. 5, h), resting in the primary vesicle, constricting and then expanding into (b) a generally rounded structure, the bulb (Text Fig. 5, b), which in turn rests in and occupies almost all of the secondary vesicle. This bulb also constricts into (c) a long thin tube, the canal (Text Fig. 5, c), which may either twist around over the bulb or run directly and freely down the lobe of cells and enter the reservoir near its base. When these cells are dissolved away with KOH the tubes may be followed individually to their points of entrance in the sac. Each enters individually, as they do not fuse into a common duct (Text Fig. 6). In many instances frontal views of the hook showed an opening (Text Fig. 6). Whether or not this actually is a lumen is hard to say. In living cells, small granules were often seen undergoing Brownian movement within the bulb.

The canals may be more than 264  $\mu$ . long and are the only structures which connect the glands with the reservoir. The canals connecting the secretory lobes with the thoracic reservoir are smaller than the canals in the abdominal glands so that the thoracic cells lie close to the surface of the sac. The lobes are well supplied with tracheae and trachioles. The hook stains very lightly with Delafield's while the bulb takes the stain heavily (Text Fig. 9). This may possibly indicate a chemical difference between these two regions. The canal also stains more darkly than the hook. With vital staining, using methylene blue, no cell boundaries could be made out and the gland appears as a syncytium (Text Fig. 5). In sections of newly emerged and older beetles, some portions of the secretory lobe could be differentiated into individual cells by clear areas where the cells appeared to have separated. Other portions of the cytoplasm run together without being separated by these areas and no cell walls were seen.

It is difficult to get an accurate measurement of the size of the lobulated aggregates, as these may be curved. There may be a great deal of variation in the number and size of the original individual cells that make up a gland and therefore the size of the gland will vary. The cells may be arranged in a circle or in a single or double row. Some measurements of vitally stained glands may be noted in order to give some idea of their relative sizes. One aggregate consisting of a double row of cells was 375  $\mu$ . long and 100  $\mu$ . wide. Another gland of 6 cells arranged in a single row was 161.7  $\mu$ . long and 49.5  $\mu$ . wide. A circular gland of cells had a diameter of 92.4  $\mu$ . The size of the primary vesicle may vary in a secretory lobe, some being slightly smaller than others, depending on the size of the original cell it is in. There was little difference in the size of this vesicle during the period 42-138 hours after emergence, the average diameter being 25.2  $\mu$ . These glands are present in both the thoracic and abdominal regions.

Thus from this description we can see that actually the lobe consists of many individual glands. The cytoplasm produces the odoriferous

substance which probably collects in the primary vesicle where it is conducted through the hook, bulb and canal and then finally stored in the reservoir. The function, if any, of the various parts such as hook, bulb, and secondary vesicle is not known.

*Origin and Development of the Secreting Cells.*—The development of the glandular cells was followed in both the thoracic and abdominal regions. The following description is based on observation of sections through the thorax of various pupal stages. In newly pupated animals, the secretory cells could not be detected. In sections of pupae with lightly pigmented eyes (3–6 days after pupation) groups of cells which apparently had broken loose from the hypodermis and migrated inward could be seen. These hypodermal cells contained large nuclei which occupied most of the darkly staining cytoplasm (Text Fig. 7). The tubes were also partly formed and many could be seen with large elongated nuclei which caused the straight canal portion to bulge (Text Figs. 7, 10, tn). At this time the canal has already entered the reservoir. These tube-forming cells are generally found close to or sometimes among the groups of hypodermal cells that are developing into the lobe (Text Fig. 7, tn). Apparently certain hypodermal cells produce the tubes. The cytoplasm from one end of these tube-forming cells develops into the long canal which eventually enters the sac while the opposite end of the cytoplasm differentiates into the bulb and hook which rest in their respective vesicles (Text Fig. 10). This differentiation into bulb and hook may take place before the vesicles are formed and therefore before the cells have matured. As the tube develops, its nucleus becomes smaller and as a result the bulge in the canal decreases and eventually disappears (cf. Text Figs. 7 and 10, tn).

When the eyes of the pupae are darkly pigmented (end of Stage I, about seven days after pupation) the bulb and hook are already formed and the secondary vesicle is clearly marked off by a membrane. The bulb rests in the secondary vesicle. The primary vesicle is not yet marked off by a membrane and is represented by a lightly staining cytoplasmic area in which the hook rests. The nuclei of the cells are still large and individual cell boundaries can still be made out.

During Stage II (about eight days after pupation) the cells are essentially the same as in the previous stage except that the cells are larger and the nuclei smaller while the clear area (the future primary vesicle) has become more distinct (Text Fig. 8, ca). Nuclei can still be seen in the tubes but these nuclei are smaller.

By Stage III (about nine days after pupation and shortly before emergence) the gland cells are fully formed and differ from those in the adult beetles in being much smaller in size and still possessing individual cell walls. A membrane now surrounds the primary vesicle and the radiating fibrillae can be seen converging toward its center. Evidently these cells in the thorax may already function at this time since secretion has been detected in a number of Stage III pupae (see Table I). Some of the canals, in animals at emergence, still contained nuclei which had become so small that the original bulge in the canal was absent. These nuclei eventually disappear.

The lobes of secretory cells in the abdomen develop in the same

manner and apparently at the same rate as those in the thorax. At emergence the abdominal glands appear as fully developed as the thoracic ones, even though the secretion can be detected in the thorax earlier than in the abdomen (see Table I).

Individual secreting cells apparently are not found on the thoracic reservoirs but are present on the abdominal ones only. These come from hypodermal cells which migrate in and become adpressed to the sac wall (Pl. II, fig. 18, sc). By Stage II these cells have fully formed canals but the clear area in which they rest is not very prominent. Whether the canal forms from the hypodermal cell which develops into the individual secreting cell or whether it is made from another hypodermal cell which is already along the reservoir wall could not be determined.

These individual secreting cells look much like some of the oenocytes which are very numerous around this region, in the newly emerged adult. However, they are not to be mistaken for them since oenocytes never possess a canal or a clear area but have a darkly staining nucleus which appears to have many nucleoli, and a more or less uniformly staining cytoplasm (Text Fig. 13). Also the oenocytes are seldom round and are distributed all over the body, either singly along the sides of the abdomen or in groups among the fat cells (Pl. II, fig. 18, o). They show a definite cycle in size, shape, and numbers, and from sections of pupae appear to arise from hypodermal cells also. Wigglesworth (1933) found that the oenocytes arise from epidermal cells in *Rhodnius*, and Snodgrass (1935) states that the oenocytes are epidermal cells which have migrated into the body.

McIndoo (1914) found that the scent glands of the honey bee also arise from migrating epidermal cells. He also observed that certain hypodermal cells form the chitinous tube and that as these tubes or long processes develop, the cytoplasm and nuclei of the cells diminish in size. He concludes that the hypodermal cell must serve as a store-room for building a tube. Apparently this is also true for the development of the tube in the secretory lobes in *Tribolium*. However, the process is probably more complex since the tube is not a straight canal, as in the bee, but differentiates into a hook and bulb which rest in the cell. The nuclei of the cells forming the secretory lobes becomes smaller as the cells mature. Since the vesicles and their membranes are not present in the early developmental stages of these cells, it is possible that the nuclei contribute some material to their formation and as a result decrease in size.

Gilson (1889) in discussing the morphological significance of the various parts of the odoriferous gland cells in *Blaps mortisaga*, states that the membrane of the vesicle, of the ampulla (a dilation at the end of the tube), and of the tube are analogous to the nuclear membrane and to other productions which arise in the cell by a condensation of the protoplasmic reticulum. The radiating filaments are nothing but radial fibres of the reticulum, which have become more regular and stronger.

McIndoo found that at emergence the gland cells seem to be perfectly developed in all respects, except that they are only about two-thirds

the size of the gland cells in older bees. He suggests that the rapid growth which takes place in these cells after emergence may be due to the fact that the gland cells suddenly begin to function. The increase in size of the glandular cells in *Tribolium* after emergence may also possibly be due to such an increase in activity. But it should be remembered that at emergence, secretion is detected in the thoracic glands only which would indicate that the thoracic glands are more active than the abdominal ones. Actually no difference in size or structure could be detected histologically. However, though secretion is detected in the thorax first, the amount present may be very minute and the actual difference in secretory activity between the cells in these two regions may be so slight as to be difficult to detect.

#### A POSSIBLE MECHANISM FOR THE MODE OF EJECTION OF THE ODORIFEROUS SUBSTANCE

From a description of the glands and from certain observations on the emission of the secretion, we may suggest a possible mechanism of ejection of the fluid from the reservoirs. The structure of the glands may be briefly summarized as follows. They consist of large reservoirs which are merely continuations of the exocuticle of the beetle. These reservoirs are easily collapsible and therefore are constantly subjected to changes in body pressures. A mechanism controlled by muscles is present for closing the opening to the outside of the abdominal reservoirs. When relaxed, these muscles keep the exit closed and when contracted keep it open. These muscles also lie dorsally, closely adpressed to the surface of the reservoir. When contracted they may have something to do with forcing out the secretion. The thoracic sacs appear to lack a closing mechanism, but muscles surround the reservoirs and their contraction would force out the secretion. The glandular secreting cells have nothing to do with the ejection of the secretion but merely produce the substance which flows through the cuticular tubes and fills the sacs where it is stored.

*Some Observations on the Ejection of the Secretion.*—1. The thoracic glands may eject independently of the abdominals and vice versa. In many animals, the secretion appears to be given off from the thoracic sacs more readily than from the abdominal ones. This could be explained by the absence of a closing mechanism for the thoracic reservoirs. However, animals have also been seen which give off the secretion readily from both the thorax and abdomen.

2. If adults are placed in a Petri dish which is kept on ice cubes contained in a finger bowl, it will be seen that they are inactivated in a few seconds and while being inactivated they give off the secretion. Generally after a slight delay, the substance is given off in such quantities that it can easily be seen, under the binocular microscope, coming from the four reservoirs. Usually the material first comes from the thoracic sacs, flows out and crystallizes around the neck and down the ventral part of the head and often flattens the antennae down against the head. The fluid from the abdominal sacs flows out and crystallizes along the sides of the body or in clumps at or near the openings of the reservoirs (Text Fig. 4, c). If these inactivated animals are placed

on acidulated KI starch papers (still kept on ice) they may continue to discolor them for more than an hour. This would give one the impression that there is a continual emission from the sacs even when the animal is inactive because of the low temperature. However, the continued discoloration of the starch paper is due to the crystals which have sublimed on the body of the beetle. If these crystals are removed with needles, they (the crystals) will continue to discolor the starch paper until completely vaporized, while inactivated beetles whose crystals have been removed discolor the test paper only slightly and the discoloring soon ceases entirely. Further evidence for a cessation of secretion soon after the initial ejection is found in the fact that only a limited amount of crystals pile up and these do not increase on the body of the animal, whereas if ejection were continuous for one hour or longer, much more of the fluid would collect. Thus when the adults are inactivated on ice, following a slight delay, there is a spasmodic ejaculation which gradually ceases.

No doubt, in nature, when *Tribolium* is disturbed the reservoirs are opened very slightly so that the amount of fluid given off is very small and vaporizes almost immediately. When adults are held on KI starch paper discoloration is noted but no fluid can be seen coming out of the openings. In other words, the vapors from the secretion discolor the paper. However, when placed on ice as described above, so much fluid is given off that it can be clearly seen coming out of the body. Doubtless the muscles controlling the exits from the abdominal reservoirs suddenly contract strongly, because of the low temperature, open up the sacs, and allow the fluid to escape in quantities much greater than would occur normally. Similarly, contraction of muscles in the thorax would force the secretion out of the reservoirs in this part of the body. It should be remembered that the sacs are continually under the influence of body pressure and if the exits were open, an increase in this pressure would force out the fluid.

After a very short while, ejaculation ceases. Three possible explanations suggest themselves for this cessation. The first is that all of the fluid is given off leaving the sacs empty. However, the sacs may still be full of oil. The second is that the oil crystallizes within the sacs themselves at the same time that the fluid crystallizes out on the body, thus preventing outflow. Evidence is against this, for after ejection has ceased it can be seen that the oil is still in a liquid state. This may be due to the fact that the body temperature of the beetle is higher than that of its surroundings. Wigglesworth (1939) states that although the body temperature of insects is generally the same as that of its surroundings, due to the balance of heat loss by metabolic production, this applies only over a moderate temperature range. Evaporation is the main factor in loss of heat, and therefore any factor which will affect evaporation will influence the body temperature. At low temperatures, evaporation is depressed and the body temperature may be greater than the outer environment. Himmer (1932) found that the body temperature of certain Hymenoptera may exceed the surrounding temperature. He measured an excess from as little as 3.08° C. (in *Polistes*) to as much as 13.73° C. (in male *Apis*). Thus

the body temperature of the inactivated *Tribolium* adults may not be low enough to cause the secretion to crystallize out within the animal.

The last and probable explanation for cessation is that the muscles controlling the openings to the abdominal reservoirs slowly but finally relax, thus closing the exit and preventing the fluid from escaping. Relaxation of the muscles would also release the pressure on both the thoracic and abdominal reservoirs.

3. It is quite possible also that the respiratory movements of the abdomen have something to do with the emission of the secretion. In *Tribolium* adults these movements consist almost entirely of a dorso-ventral flattening of the abdomen accomplished by means of lateral tergosternal muscles. The sterna are firm and convex while the terga are mobile and rise and fall with each inspiration and expiration. Undisturbed *Tribolium* adults show very slight respiratory movements and generally move very little. However, when irritated by stroking, low or high temperatures, light, etc., they become very active and their respiratory movements increase greatly, possibly because of a stimulation of the respiratory centers. Stahn (1928) believes that any stimulus will cause an increase in respiration in insects. There also seem to be some slight longitudinal telescopic movements of the abdominal segments shortly before emission of the gas, and most of this movement is confined to the last three abdominal segments and the last abdominal sclerite often bends downward. Undoubtedly all these movements tend to increase the blood pressure of the beetle, which in turn would tend to constrict the collapsible reservoirs. Abdominal movements would also influence the thoracic sacs since any increase in abdominal pressure would be transmitted through the haemolymph and affect the thoracic reservoirs. However, it is necessary for the abdominal sac to be opened by the contraction of the duct muscle before any secretion is emitted. Thus it is possible for the beetle to increase the body pressure by these various abdominal movements, and still not give off any secretion, a phenomenon which was often observed.

#### THE KI STARCH TEST AS AN INDICATOR FOR THE PRESENCE OF ODORIFEROUS GLANDS

It is quite possible that many of the odoriferous substances given off by insects are oxidizing agents and will discolor acidulated KI starch paper. If this is so then we have a very simple method for determining the presence of such secretions, for merely holding an insect on this paper will show immediately whether or not such a substance is present. However, the failure to discolor this test paper does not necessarily mean that such glands are absent. It is suggested that other insects be tested with this indicator.

Other species related to *Tribolium* were examined in this manner for the presence of odoriferous glands. *Gnathoceros cornutus*<sup>5</sup> was found to have two large abdominal reservoirs (Pl. I, fig. 5) attached to

<sup>5</sup>The author wishes to thank Dr. T. H. Park, of the University of Chicago, for a culture of *Gnathoceros*, and the American Museum of Natural History, and Miss Ethel Poris, of Washington Square College, for a supply of *Tenebrio*.



the last abdominal sclerite and opening laterally on either side of the anus. These sacs are striated, elongated, tapering and round at the apex, and narrow down to a small neck at the point of attachment. The striated appearance is quite similar to tracheal rings. The secretion which gives the oxidizing test on KI starch paper, may be in the form of a yellow oil which often lies at the rounded apex of the sac (Pl. I, fig. 5, s). At other times long thin yellow crystals are seen in the reservoirs (Pl. I, fig. 6, c), either with or without the oily fluid. The presence of crystals in the sacs is not unknown. Gilson (1889) found in *Blaps mortisaga* that the secretion is an oil in which swims a considerable number of crystalline yellow needles. Unlike the *Tribolium* reservoirs, the *Gnathoceros* sacs may be in an expanded state even though they are not filled with secretion. This is probably due to the fact that it is a striated structure (Pl. I, fig. 6).

The adults of both sexes of *Tenebrio molitor*<sup>5</sup> also possess a pair of glands whose secretion discolours KI starch paper. These are two eversible repugnatorial glands, noted by Valentine (1931), which are attached to the last abdominal sclerite. These organs consist of glandular secreting cells and an evaginable membrane which has a sac-like, tapering, appearance when everted. This structure is a continuation of the pleural membrane of the last abdominal segment. When everted the organ has a glossy, fleshy, appearance (Pl. I, fig. 7). Actually it is a very thin membranous structure about 2 mu. thick. A black, apparently non-crystalline, solid substance clings to the exposed surface of the membrane, when everted (Pl. I, fig. 7, so), and most of it adheres to the sac wall when that structure is withdrawn.

Everted (by pressure of a needle on the abdominal sclerites), the sacs may measure 800 mu. long and 400 mu. wide near the point of attachment (there is a slight difference in size of males and females). In their retracted state these same structures average 560 mu. long and 750 mu. wide. When withdrawn, the membrane is folded into two more or less rounded structures (Pl. I, fig. 8) which usually do not extend farther than the upper margin of the last abdominal sclerite. In this condition the lobes of secretory cells are found over the surface of the membrane and many minute tubes lead from these cells to the membrane. This can be clearly seen when the glands are dissected out in distilled water and vitally stained with methylene blue. Tracheae ramify over the cells and may serve to hold these lobes in place.

The membrane is insoluble in concentrated  $H_2SO_4$ . The last abdominal segment plus the eversible membrane was dissected out and subjected to the chitin tests described for *Tribolium*. The membrane gave excellent tests for both chitosan sulphate and the deep reddish violet color with the iodine-dilute acid solution, after being subjected to the alkali treatment.

A more detailed study of the odoriferous glands of *Gnathoceros* and *Tenebrio* is being undertaken.

<sup>5</sup>See footnote p. 419.

## DISCUSSION

Dimmock (1883), Packard (1896), and McIndoo (1914) give extensive bibliographies on the odoriferous glands in insects.

McIndoo divides the scent producing organs into five types, based on their devices for disseminating the odor and for storing the secretion, as follows:

1. No special device for disseminating the odor or storing the secretion.
2. Gland cells associated with hairs and scales as a means of scattering the odor more effectively.
3. "Evaginable" sacs lined with hairs connected with gland cells as a device for storing and distributing the odor.
4. Articular membranes serving as pouches for storing and preventing a too rapid evaporation of the secretion.
5. Specialized tubes and sacs acting as reservoirs for storing and discharging the secretion.

The author gives numerous examples for each type. The glands in *Tribolium* and *Gnathoceros* obviously belong to division 5, while those of *Tenebrio* to type 3. McIndoo states that the organs belonging to the first four types are probably used for alluring purposes and as a means of recognition, while the fifth type is probably only used as a means of defense. However, Valentine (1931), in writing of the musky odor given off by the odoriferous glands of *Tenebrio* (type 3), states that it is probably merely an offensive emanation useful as a means of protection.

*Tribolium confusum* is often heavily infested with mites, the most common species being *Acarophenax tribolii*. The author has seen numerous mites, generally clinging to the ventral surface of the thorax and abdomen. Apparently the odoriferous glands offer no protection from these parasites. Washburn (1904) has reported the adult cadelle, *Tenebroides mauritanicus* L., as eating flour beetle larvae and adults, while Back and Cotton (1926) found that adults of *Tenebroides* will attack and devour the larvae of almost any insect they encounter. However, further experiments indicated that cadelle larvae are not usually predacious, and Good (1936) states that "cadelle larvae showed no tendency to attack larvae, pupae, or adults of *Tribolium*." Good also found the predacious *Xylocoris cursitans* (Hemiptera) attacking small larvae of *Tribolium confusum*. Except for mites, it seems from available data that *Tribolium* adults are seldom, if at all, attacked by other insects.

Some interesting observations have been reported regarding the mixing of *Tribolium* with other species. Good (1936) states, "... it has frequently been observed that in cases where *Tribolium* and other species of insects are present in the same breeding jar the *Tribolium* will soon crowd out the other insects. Whether this is due to the killing of other insects or mechanical crowding is a matter of conjecture." Park (1939) reports that "... in mixed populations, *Tribolium* appears to drive out *Trogoderma* irrespective of initial densities." In a personal communication Park (1940) writes, "I

rather imagine that although you will discover some population effects that can be correlated with the scent it will not prove to be the only or most important factor. In our mixed population studies we completely renewed the medium every 30 days. This, of course, would prevent any odor from accumulating to any great extent. . . . *Tribolium* does not always drive out *Gnathoceros*. There are instances when the latter is the winner, also *Trogoderma* is always driven out after a varying interval of time by either *Tribolium* or *Gnathoceros*. (It will be recalled that *Gnathoceros* has a pair of well developed odoriferous glands.)<sup>6</sup> . . . It is quite possible that the scent will prove to be a partial explanatory factor."

Chapman (1928) observed that irrespective of initial population density, eventually an equilibrium is attained after which the *Tribolium* population becomes relatively constant. It is known, too, that unless the medium is changed regularly, *Tribolium* cultures will decline and eventually die out. Park (1936) suggests that self-conditioning of the environment by the beetles is a factor which contributes to the decline of their populations, considerably before the culture reaches a decadent state. It is very possible that the secretion given off by *Tribolium* adults may have some influence on making for a static population and for eventually causing a decline in their numbers. If this is true, it is interesting to note that here is a case where an insect has a so-called protective device which in the long run may prove to be detrimental to the species itself.

As early as 1826, Dufour described the odoriferous glands of some Carabidae which, though much simpler than those of *Tribolium*, possess secretory cells with conducting tubes, and a reservoir. Leidy (1849), writing of invertebrate odoriferous glands, says: "Although varying in the degree of their complexity in different animals, and in the character of their secretion, yet the essential structure is the same throughout. Consisting of tubes or follicles of basement membrane, their complexity depends upon their greater or lesser length, their being simple or compound, straight or more or less convoluted, and isolated or aggregated in connection with the mode of supplying to them their nutritive fluid."

Cells with structural differentiations somewhat similar to those in *Tribolium* have been found in *Brachinus* (Karsten, 1848), (Dufour, 1826), *Blaps mortisaga* (Gilson, 1889), *Belostoma* (Dahlgren and Kepner, 1908), and in Forficulidae (Vosseler, 1890). However, these are not as complex as those in *Tribolium*. The secretory cells of *Blaps* come closest to the structure described in this paper, yet *Blaps* possesses only one vesicle and its chitinous tube merely dilates at the end. Gilson states that the odoriferous cell of *Blaps* represents the most complex type of unicellular gland and one of the most complicated forms of living cell. The odoriferous cells of *Tribolium* have reached a state of even greater complexity.

What the significance of the structural differences in these cells in the various species is, one cannot say. Perhaps they represent stages in the evolution of the unicellular odoriferous gland. It is possible

<sup>6</sup>Words in parentheses are the author's.

that the individual and paired cells of *Tribolium* actually represent a stage in the development of the more complex lobe found in the same animal. However, no intermediate stages between these two vastly different cells were noted.

Lastly we come to the secretion which these glandular cells manufacture. Is the end product of the cells influenced by the various structures in the cell? Does the chemical substance produced increase in complexity with the increase in complexity of the secretory cells in the various forms? The first step in the answer to these questions must be the chemical analysis of these odoriferous substances.

### SUMMARY

1. The adults of both sexes of *Tribolium confusum* Duval possess two pairs of well developed odoriferous glands, one pair in the prothorax and the other in the abdomen. Each gland consists of a chitinous reservoir, continuous with the exocuticle, in which the secretion is stored, and glandular cells which manufacture the odoriferous substance.

2. The thoracic reservoirs open to the outside at each apex and rounded front angle of the prothorax, close to the head at about the level of the intestine. The abdominal sacs open through the last abdominal pleurites on either side of the anal opening at the point on the last abdominal sclerite where the lateral margin projects conspicuously and where there is an indentation immediately to the rear of these projections.

3. The glandular cells are of two main types: (1) individual or paired cells with small cuticular tubes leading into the sac, which appear to be present on the abdominal reservoirs only and absent from the thoracic ones; (2) another type which is much more complex and consists of lobulated glands. Each gland cell contains a primary and secondary vesicle with radiating fibrillae converging in the primary vesicle. A tube which is differentiated into a hook, bulb, and canal leads from the vesicles to the reservoir. The lobe in the adult beetle is a syncytium. The gland cells arise from hypodermal cells and may be detected about three days after pupation.

4. The secretion may be detected in the thoracic glands of some very late pupae which are shortly to emerge. In newly emerged adults the secretion is present in the thorax only. The substance is definitely detected in the abdominal glands two hours after emergence. Starvation has no effect on the initial production of the secretion.

5. It is suggested that the KI starch test be used as an indicator for the presence of odoriferous glands in other insects.

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SIPHONAPTERA: SPECIES AND HOST LIST OF MONTANA FLEAS, by WILLIAM L. JELLISON, GLEN M. KOHLS, and HARLOW B. MILLS. Pages 1-22, paper bound, 6 x 8¾ inches. Misc. Pub. No. 2, MONTANA STATE BOARD OF ENTOMOLOGY, Helena, Montana. 1943.

This pamphlet contains a list of 64 species of fleas and their hosts in Montana, and a list of 51 mammal hosts and the fleas recorded from them.—D. J. B.

# A NEW GENUS AND NEW SPECIES OF SYRPHIDAE (DIPTERA) FROM ECUADOR

C. L. FLUKE,  
University of Wisconsin,  
Madison, Wisconsin

## Tuberculanostoma new genus

Small, shining black or blue black species with the face produced forward into a snout and with a very prominent tubercle. Head wider than the thorax. Eyes bare. Antennae medium to elongate, the arista dorsal and basal. Cilia on the upper occiput exceedingly long. Metasternum bare. Scutellum somewhat triangular, rugose, and usually with two slender bristles on the rim near the tip. Notopleura without a distinct tubercle. Otherwise like *Melanostoma*. Type of genus, *T. antennatum* n. sp.

In the genotype the front is broad and long, the antennae are elongate, the eyes of the male are dichoptic, and the genitalia are larger than normal for a small species. A second related species is similar but the genitalia are normal in size. Two other species are intermediate with holoptic eyes, shorter antennae, smaller front, but with a curved hair on the front femora of the male as is found in *Melanostoma ambiguum* Fallen. These latter two species indicate the close relationship of *Melanostoma* and may not be considered by some workers distinct enough to be included in *Tuberculanostoma*. The snout on all four is very similar but the tubercle does vary as indicated in the key and illustrations. These species all lack the notopleural tubercle that is so common on species of *Rhysops* and *Melanostoma*. They all form a very compact group and were collected at high altitudes in Ecuador by my friend F. Martin Brown. The holotypes are deposited in the American Museum of Natural History, New York City.

## KEY TO SPECIES

1. Males.....2  
Females.....5
2. Eyes dichoptic, no peculiar curved hair at tip of front femora.....3  
Eyes holoptic, front femora near tip with a black curled bristle.....4
3. Genitalia large with long slender styles, facial tubercle nearer antennae than tip of snout.....**antennatum**  
Genitalia normal, styles not exceptionally long, facial tubercle midway between oral tip and base of antennae.....**ciliium**
4. Hair of front femora and tibiae curly in addition to the single curled bristle.....**browni**  
Stiff black bristles basal to curved bristle at tip of front femora (female unknown).....**pectinis**
5. Abdomen opaque with shining spots in the basal corners of the 3rd and 4th tergites, facial tubercle closer to oral tip than base of antennae, mesonotal pile mostly white.....**browni**  
Abdomen shining, facial tubercle not closer to oral tip than base of antennae, mesonotal pile mostly black.....6
6. Shining blue, antennae reaching almost to oral tip, front shining...**antennatum**  
Color more greenish black, very little blue; antennae shorter, front with an opaque band.....**ciliium**

***Tuberculanostoma antennatum*** new species

Figures 1, 2 and 3

Shining blue black, the antennae extending to the tips of the oral margin, eyes of the male dichoptic, genitalia large with long curved styles. Length 5 to 6 mm.

*Male*.—Head shining blue black with a rather large frontal triangle which is lightly white pollinose but with black bristly pile. Face well protruding forward, but not at all downward; a very prominent tubercle, which is closer to the antennal base than to the oral tips; sides of the face and cheeks very lightly white pollinose and with white pile. Eyes distinctly dichoptic. Ocellar triangle and upper occiput black with long black cilia. Antennae elongate, third segment equal to the first and second together, the first slightly longer than the second; third segment distinctly constricted on the basal third; arista basal, about the same length as the third segment, briefly pubescent.

Thorax everywhere shining blue black; pile of the mesonotum black, the scutellum black on the disc, but with white hairs along the edges; at the apex two widely separated rather long, slender black bristles; on each side of these terminal hairs there are often three or four more although they are usually shorter. Ventral fringe short, thin and white. Pile of the pleura sparse but practically all white. Legs everywhere black and the pile mostly whitish except on the middle tibiae where it is short and black. The hairs on the upper sides of the tarsi are usually black. On the under sides of the hind tarsi, the hairs form almost a thick yellowish mat.

Wings hyaline, blackish toward the base, the stigma yellowish. The costal margin with a fringe of short, black bristle-like hairs. Squamae white with yellowish fringe; plumule very much abbreviated, yellowish-brown in color; halteres yellow, the stalks brown.

Abdomen everywhere shining bluish-black. The pile practically all whitish, becoming black on the genitalia; the genitalia are quite large and the styles are extremely long and slender. In the preserved specimens, the abdomen has a constricted appearance at the apex of the third segment; at the point of extreme constriction, the abdomen is only half or one-third as wide as at the apex of the second segment.

*Female*.—Very similar to the male; the front rather wide, about three times as wide as the ocellar triangle and becoming considerably wider across the antennae; the pile all black. Antennae slightly shorter than on the male and the third segment not so conspicuously constricted. Abdomen more oval, but very highly polished blue-black.

*Types*.—Holotype male, Hda. Talahua, Province of Bolivar, 3100 meters, Ecuador, April 29, 1939 (F. M. Brown); allotype female, same place, April 28, 1939. Paratypes: one male, same data as holotype; three males and two females, same data as allotype.

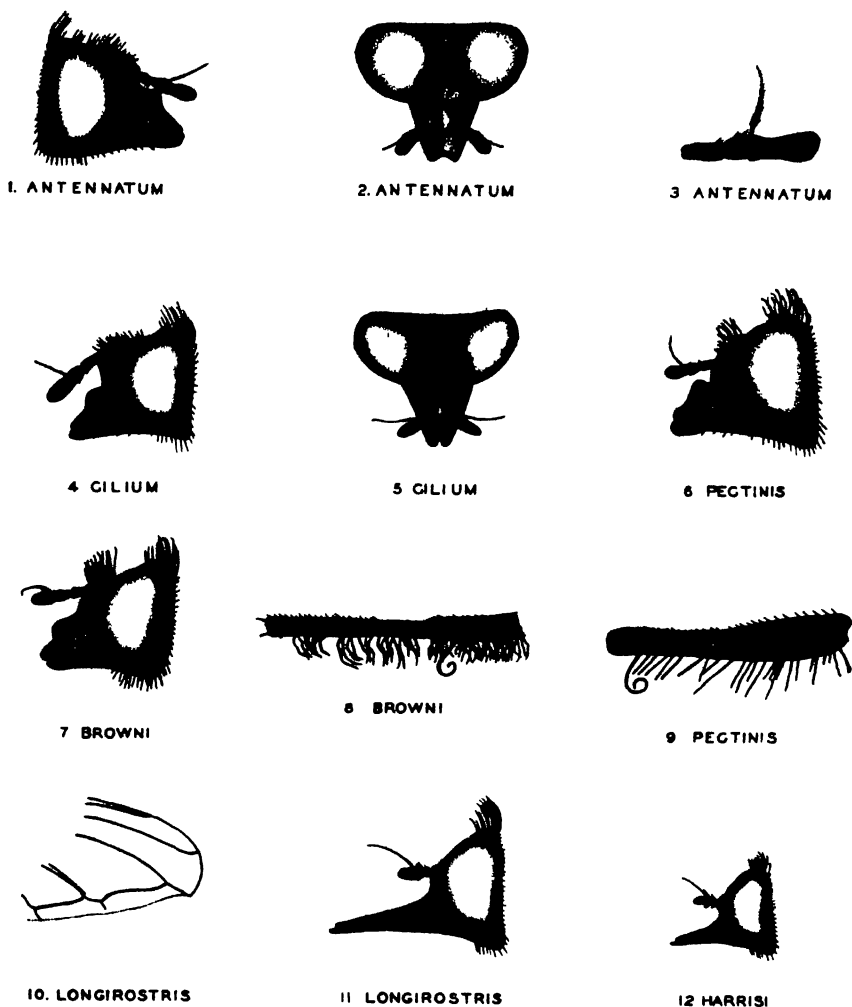


Figure 1. *Tuberculanostoma antennatum*, new species, profile of head of male. 2. *T. antennatum*, new species, top view of head of male. 3. *T. antennatum*, new species, antennae of male, inside view. 4. *T. cilium*, new species, profile of head of male. 5. *T. cilium*, new species, top view of head of female. 6. *T. pectinis*, new species, profile of head of male. 7. *T. browni*, new species, profile of head of male. 8. *T. browni*, new species, tibia and apical half of femur of male. 9. *T. pectinis*, new species, femur of male. 10. *Rhingia longirostris*, new species, apex of wing. 11. *R. longirostris*, new species, profile of head of male. 12. *R. harrisi*, Curran, profile of head of male.

All drawings were made with the aid of the camera lucida; head views were made to the same scale.



***Tuberculanostoma cilius* new species**

Figures 4 and 5

Similar to *antennatum* but the tubercle is not so prominent and is placed midway between the antennal base and the oral angles. The antennae are also shorter. The abdomen is slender with parallel sides and the genitalia are normal. Length 7 mm.

*Male*.—Head shining black with bluish-green reflections. The frontal triangle large and lightly coated with brownish pollen, along the eyes with black pollen. Face considerably excavated above the tubercle and the upper slope of the tubercle forms a right angle with the line coming from the base of the antennae; slopes of the face and cheeks lightly dusted with white pollen which is somewhat darker just below the tubercle, the pile all whitish. Ocellar triangle equilateral with black pile and the cilia long and all black; the upper occiput shining and with short yellowish hairs. Eyes dichoptic, bare. Antennae dull black, reaching only to the upper oral edge, the first two segments together as long as the third, the third elongate and only slightly constricted near the base; arista black, pubescent, slightly longer than the third segment.

Thorax entirely shining blue-black with very fine dark pollen on the disc of the mesonotum and white pollen on the pleura; pile of the mesonotum sparse with the longer hairs black and the shorter hairs whitish, the white hairs more common across the front and along the sides. Scutellum shining with rather definite preapical depressions, in front of this, very faintly rugose; two long black apical bristles and a similar one on each side toward the base but more on the disc than on the rim; the rest of the pile is quite short, black and yellow mixed, the fringe whitish.

Legs entirely shining black with sparse white pile but with black pile on the outer sides of the femora and the upper sides of the four front tibiae and upper sides of all the tarsi. No peculiar hairs present anywhere.

Wings very slightly smoky, darker at the base, the stigma yellowish; squamae white with yellowish fringe; plumule slender and whitish at the tip, but brownish at the base; halteres yellow, their bases black.

Abdomen highly polished, only slightly opaque on the disc of the second segment and base of the third segment. Sides nearly parallel and narrower than the thorax, the pile whitish, becoming all black on the genitalia; a rather heavy tuft of black hairs on the bases of the styles. Genitalia much smaller than on *antennatum*.

*Female*.—Front shining on the lower half, the upper half dark pollinose including the ocellar triangle; lower half very lightly coated with gray pollen. Mesonotum shining blue-greenish with a triangular dull area in front of the scutellum, this dull spot reaches almost to the middle of the mesonotum. The abdomen quite slender, but more oval than the male, no apparent dull markings on any of the tergites.

*Types*.—Holotype male, Minza Chica, Volcan Tungurahua, Ecuador, 3200 meters, April 8, 1939 (F. M. Brown). Allotype female, Hda.

Talahua, Province of Bolivar, 3100 meters, Ecuador, April 28, 1939 (F. M. & H. Brown).

***Tuberculanostoma browni* new species**

Figures 7 and 8

Eyes of the male holoptic, tubercle of the face nearer the oral tips than base of the antennae; antennae short, the third segment oval; male front femora at the tips with a peculiar curved hair, other hairs on the front femora and tibiae shaggy; the abdomen mostly opaque, the genitalia small. Length about 6 mm.

*Male*.—Front normal, black with dark pollen and black pile; face highly polished, blue-black, the slopes next to the eyes with a small patch of dark pollen, the pile yellowish; cheeks shining black with white pile; ocellar triangle semi-shining black with black pile; the cilia long and black but with some shorter white hairs; the occiput gray pollinose and with whitish hairs. Eyes holoptic, bare. Antennae short, reaching only to the tips of the tubercle, the third segment heavily brownish pollinose; arista considerably thickened at the base, very faintly pubescent.

Mesonotum shining black, lightly brown pollinose which forms two very faint vittae at the middle; the pile rather long and mostly black, becoming white along the sides. Scutellum triangular, slightly rugose, pile long and black with six to eight bristle-like hairs on the margin, on the disc with shorter white hairs, the fringe short and white. Pleura rather highly polished, lightly dusted with white pollen; the pile brownish on the upper third of the mesopleura, other areas very sparse and white.

Legs black with mostly whitish pile; at the tips of the front femora a peculiar long, curved black bristle in addition to shaggy black and white hairs which become normal and are white at the base; on the outside of the front tibiae long, curly hairs which are black. Wings dilutely brownish, darker at the base, the stigma yellow; squamae yellowish-brown; plumule white; halteres yellow, the stalks black.

Abdomen opaque black, shining along the sides and on oval spots in the anterior corners of the third and fourth tergites; apex of the fourth segment, all of the fifth, and the genitalia highly polished. Venter shining, lightly dusted with white pollen, the pile rather long and white. Pile of the abdomen is white on the shining areas and mostly black and appressed on the opaque areas.

*Female*.—Front wide, very highly polished, but with a white pollinose triangle on each side on the lower half of the front next to the eyes; this triangle connects with the spot on the slopes of the face. Mesonotum semi-shining with brown pollen which forms three faint vittae especially on the posterior half. Pile of the mesonotum mostly short and yellowish with a few longer black hairs; pile of the scutellum almost entirely white; pile on the upper pleura all whitish. Abdomen similar to the male but more oval with the usual shiny side spots.

*Types*.—Holotype male, Urbina, Cerro Chimborazo, 3650 meters, Ecuador, April 18, 1939 (F. M. & H. Brown); allotype female, Hda.

Talahua, Province of Bolivar, 3100 meters, Ecuador, April 28, 1939 (F. M. Brown). Paratypes: four males, five females, same data as on the holotype; two males, five females, Cambre de Tililac, Cerro, Chimborazo, 4200 meters, Ecuador, April 21, 1939; two females (same data as allotype).

***Tuberculanostoma pectinis* new species**

Figures 6 and 9

Tubercle nearer base of antennae than oral tip, front femora of male with a curled bristle and several strong black bristles basally, abdomen opaque with shining side spots. Length 6 mm.

*Male*.—Front broad, heavily coated with brown pollen which extends along the eyes to a larger triangular area just above the facial slit; pile of the front black. Face shining blue-black, dusted with white pollen, the tubercle rather large and highly polished; pile sparse, black above and white underneath and on the cheeks. Ocellar triangle shining with black pollen, the cilia long and black. Antennae black, first two segments subequal, the third shorter than the first two combined; arista black and thickened about the basal third and briefly pubescent. Eyes holoptic.

Thorax shining blue-black, mesonotum very lightly dulled with brownish pollen, pile rather long and black, but with shorter white hairs intermixed; scutellum with four or five transverse depressions, the pile long and black but with very short white pile intermixed, the fringe short and white. Pleura rather highly polished blue; the pile mostly pale, a few black hairs at the base of the plumule. Legs everywhere black; the pile black and white with a row of about seven or eight strong bristles on the outer sides of the front femora towards the tip; near the end of the front femora a strong black curled bristle. Wings hyaline, very slightly infuscated, the stigma yellow; squamae yellow; plumule dark brown; halteres yellow, the stalks black.

Abdomen with parallel sides, mostly opaque with highly polished triangles on the sides of each segment; apex of the fourth and following segments entirely shining. Pile mostly whitish or yellowish with blacker hairs toward the tip. Venter highly polished. Genitalia normal.

*Types*.—Holotype male, Hda. Talahua, Province of Bolivar, 3100 meters, Ecuador, April 28, 1939 (F. M. Brown).

***Rhingia longirostris* new species**

Figures 10 and 11

Shining aeneous to blue. Fore margin of wings black. Snout long and slender, about 3 mm. in length. Body length 11 to 12 mm.

*Male*.—Head shining dark brown to black. Front black, lightly gray pollinose, especially along the eye margins; a narrow depression running from the shining arch to the vertex of the front. Snout long and cone shaped, mostly shining and very lightly pollinose on the face, lower slopes shining translucent. Cheeks yellowish

brown, lightly gray pollinose and with white pile. Ocellar triangle almost equilateral, opaque black and with long black pile. Upper occiput extremely thin with long, black cilia and a few shorter white hairs the entire length; lower occiput gray pollinose with white pile. Facets of the compound eye considerably enlarged on the upper third. Antennae reddish yellow, arista long and slender, very briefly pubescent.

Thorax shining black to reddish brown, the mesonotum with two broad, gray pollinose bands anteriorly, which end at transverse suture; the pile sparse but quite long and all black on the posterior half, shorter and with a few yellow hairs in front. The humeri and notopleura lightly gray pollinose, the latter with three or four long bristle like hairs; four or five bristly hairs on the postalar callosities. The pleura shining black, very lightly dusted and with brownish to black pile; a rather strong bristle or two on the upper edge of the mesopleura. Scutellum shining, brownish translucent with long, black hairs on the disc and a few shorter white ones next to the mesonotum, the rim with about ten long, black bristles; the ventral fringes white and long.

Legs shining, reddish brown to blackish; the pile practically all black, which is extremely long on the outer edges of the femora, basal hairs of the femora partly yellowish; at the apex of the second and third femora the long black hairs are curved outward.

Wings brownish, somewhat darker along the veins and almost black in the stigma and marginal cells; slightly cut in at the apex just beyond the tip of the third longitudinal vein. Squamae papery and mostly white in color with brown edge and long brown fringe; plumule yellowish; halteres yellow with brown knob.

Abdomen shining blue, the first segment and basal half of second segment more yellowish to brownish; pile short and appressed, yellow, longer and more erect along the sides.

*Female*.—Very similar, the front shining aeneous, very lightly brownish pollinose with black pile.

*Types*.—Holotype male, allotype female, Hde. Talahua, Province of Bolivar, Ecuador, 3100 meters, April 29, 1939 (F. M. Brown). Paratypes: one male and four females (same data). Received from Dr. C. H. Curran.

This species is separated from *harrisi* Curran (Figure 12) and other species known to me by its unusually long snout and dark wings.

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THE BRAIN OF *DROSOPHILA MELANOGASTER*, by MAXWELL E. POWER.  
Jour. Morph. 72(3): 517-552, 6 figs. and 4 pls. 1943.

While it is not the *Annals*, general practice to notice papers that appear in other journals, this good piece of work (in a much neglected field) coming from the Yale Laboratories rates attention. When insect behavior is finally analyzed behaviorists should be able to correlate it with brain structure. This micro-study is one of the too infrequent efforts to describe the minute anatomy of the insect brain. The students of the genetics of *Drosophila* where so many mutations in the eye have been recognized are those who have an immediate interest in the accompanying brain structures.—C. H. K.

# THE METAMORPHOSIS OF THE NERVOUS SYSTEM OF *Aedes dorsalis* Meigen<sup>1</sup>

(Diptera: Culicidae)

TYLER A. WOOLLEY,

University of Utah,  
Salt Lake City, Utah

This paper presents the results of an investigation of the histological and morphological changes occurring in the nervous system of *Aedes dorsalis* during metamorphosis. It is similar to that of Richins (1938) on the digestive tract of this species.

During metamorphosis various related and interdependent changes occur in the tissues and in gross structure. Many workers have demonstrated that each system of the body is subject to some type of alteration. Much of the research on the metamorphosis of insects has been limited to the changes which occur in the gross structure of organs, but a few writers have been concerned with the histological changes as well. These latter investigators have observed the breakdown of tissue and its reconstruction, the production of new tissue, the influences one organ has upon another, and the effects produced by the changes in each stage of development.

A review of the literature on metamorphosis seems to indicate that there are two groups of insects with respect to the changes of the nervous system: one group that is characterized by a marked degeneration and phagocytosis of the nerve tissue, and a second group that exhibits slight disintegration and histolysis of the nerve tissue *in situ* but is not characterized by phagocytosis.

"Histolysis of the larval nerve-cells, inferred by Weismann . . . for muscids, was first adequately proved by Bauer . . . for various insects." (Murray and Tiegs, 1935.) Tiegs (1922), discussing *Nasonia*, reported that complete destruction of the larval nervous tissue occurred. This was also reported by Sanchez for various insects. (Murray and Tiegs, 1935.)

Murray and Tiegs (*l. c.*) found that throughout the larval life of *Calandra* (Coleoptera) mitosis of cells may be seen, particularly in the later instars, and that active mitosis occurs in the cells comprising the optic lobes. Disintegration and phagocytosis of the larval nerve cells, however, occurs rarely, and degenerating nerve trunks are never found. The cells of the membrane investing the nervous system undergo similar changes.

<sup>1</sup>This paper is an abridgement of a thesis written at the University of Utah in partial fulfillment of the requirements for the degree of Master of Science.

In the preparation of this paper the author wishes to express his gratitude to Dr. R. V. Chamberlin, head of the Department of Zoology at the University of Utah, to Drs. Don. M. Rees, W. W. Newby, and Seville Flowers, who acted as a graduate committee, and to Dr. David T. Jones and other friends who were helpful and encouraging.

Schrader (1938), in discussing *Ephestia kuhniella* (Lepidoptera), states that the functional nerve cells of the larva do not divide during larval life, and that during the metamorphosis the larval brain cells degenerate *in situ* sporadically without phagocytosis. He also relates that all neuropile differentiations of the full grown larva are already present at the time of hatching. The brain increases much less in size than the body during the larval life, and its enlargement depends almost entirely upon an increase in number of cells.

Cody and Gray (1938), discussing the changes of the supraoesophageal and suboesophageal ganglia of *Passalus cornutus* (Coleoptera), state: "The principal change is in their size and this seems to be merely a matter of growth, as they retain their proportionate size in relation to the other ganglia." They further state that in the larval instars there is a noticeable, although very gradual, change in the nervous system. The number of ganglia remains constant, but those of the abdomen become more spherical and increase somewhat in size with the growth of the larva. The most marked change consists of a slow shortening of the connectives and consequent moving forward of the abdominal chain. In contrast to this slow and gradual change in the larva, Cody and Gray relate that there is a rapid increase in concentration of nerve tissue immediately after entrance into the pupal stage. This concentration continues until emergence.

Snodgrass (1924) states that the nervous system of *Rhagoletis pomonella*, the apple maggot, undergoes more or less change in the pupa to arrive at the imago form. These developments are matters of direct transformation by growth of the nervous tissue.

Robertson (1936), found that in *Drosophila* no degenerative changes in the brain were observed and that the brain persists and grows throughout the period when other organs are degenerating.

*Aedes dorsalis* was found to be typical of the second group mentioned above; the nervous system does not undergo marked tissue degeneration, and the histolysis which does occur takes place *in situ* without phagocytosis.

## MATERIALS AND METHODS

Material for this study was obtained from shallow pools of marshes and meadows west of Salt Lake City, Utah, and was transported to the laboratory in jars of water from the original habitat. Upon arrival at the laboratory the material was placed in culture jars over which were placed glass lamp chimneys to facilitate the capture of the adults for subsequent identification. Water from the original habitat was added to the culture jars from time to time to replenish the food supply of the larvae and to replace water lost through evaporation.

The larvae were identified individually under a binocular microscope. The larvae of *A. dorsalis* were placed in separate culture jars to develop while larvae of other species were discarded. Some of the larvae were reared to adults to check upon the identifications, and others were separated into sizes and allowed to develop. The latter were observed carefully, and, when moults occurred, some of the new instars were killed in fixative and others allowed to develop further. This provided a suitable series of specimens for study, and the various instars were found to be quite constant in developmental structures.

After the larvae had reached the fourth instar, the last larval stage, they were placed in separate jars for observation. They were examined every hour, and those which had pupated were taken out of the jars and the time recorded. The pupae thus obtained were then allowed to develop at a temperature of 23°-27° C. Pupae were killed at six-hour intervals up to fifty-two hours, the average time of emergence. They were killed in fixatives and preserved in 70% alcohol for further use.

Richins (1938) was followed closely in technique.

## METAMORPHOSIS OF THE NERVOUS SYSTEM

*Metamorphosis of the Brain* (Plates I-III, IX).—The brain of the immature larva undergoes no great change, other than growth, in its development into the brain of a mature larva. The latter has a horizontal position and occupies approximately one-half of the cranial cavity. The brain is rather elongate and quite compact. Its crura cerebri are long and enter the small suboesophageal ganglia which lie in the neck region (figs. 3 and 4). The cells of the mature larval brain exhibit mitosis. The dividing cells are usually peripheral in position, but a few cells in the mid-portion of the gray matter show division.

During pupation the brain grows rapidly, and the lobes become larger and more bulbous. The brain becomes compacted into a fused mass which occupies approximately two-thirds of the cranial cavity. The compound eyes develop simultaneously with the growth of the brain, keeping pace with the enlarging optic lobes. In addition to the rapid growth of the cells there is a marked forward concentration of the nerve elements of the brain. The crura cerebri shorten, and the suboesophageal ganglia move into the head cavity from the neck region (see Plate II). These ganglia and the crura increase in size and become fused with the tritocerebrum (figs. 6 and 7). The crura cerebri remain no longer visible as distinct connectives. These structures so closely invest the oesophagus that in section it is difficult to distinguish the latter, except under high magnification (400-900×). During pupation of the larva numerous mitotic figures may be seen in the nerve cells of the brain. These figures, as in the larva, usually occurred in the peripheral cells, but a few cells of the mid-portions were seen dividing. Histolysis of the nerve tissue takes place *in situ* without phagocytosis. The new cells seem to be proliferated from the periphery of the brain, and the nerve cells of the midportions remain functional. Dividing cells were observed in newly emerged adults, but were not found in older specimens.

The brain of the imago (Plate III) is slightly larger than the pupal brain, and the lobes are well defined. The optic lobes reach their full development and appear fan-shaped. The three parts of the brain are fused with the suboesophageal ganglia and the crura cerebri into one neuropile. The compound eyes reach their full development and comprise almost the entire lateral head margin, approximating the expanded, fan-shaped optic lobes (fig. 8). The frontal ganglion remains quite constant in histological structure from the larva to adult, but shows slight modifications in shape (see Plate IX).

*Metamorphosis of the Thoracic Ganglia* (Plates IV-VI).—In both the immature and the mature larvae there are three pairs of thoracic

ganglia (fig. 15). Those of the mature larva differ only in size from those of the immature larva. Many of the peripheral nerve cells of the thoracic ganglia of the mature larva are in active division. The metathoracic ganglia of the mature larva are larger than the other two pairs, and during pupation they grow and become about twice as large. As a result they extend forward, meet the mesothoracic ganglia, and fuse with them. Thus these two pairs of ganglia appear as one large pair, the meso-metathoracic ganglia (figs. 20, 22).

The thoracic ganglia of the imago (Plate VI) appear as two pairs, the prothoracic and the meso-metathoracic ganglia. The latter innervates the wings and meso- and metathoracic legs. There is little evidence of mitosis in the nerve cells of the adult except in newly emerged specimens.

Histolysis is similar to that in the brain, and occurs *in situ* without phagocytosis; the new cells seem to be proliferated from the periphery of the ganglia.

*Metamorphosis of the Abdominal Ganglia* (Plate VII).—There are eight pairs of abdominal ganglia in both the immature and the mature larvae. Those of the mature larva are larger than those of the immature larva, although similar in structure. Mitosis was observed in the cells of both stages.

The chain of ganglia is shortened by the disappearance of the last pair of larval ganglia and its connectives, during the first hour of pupation. This last pair of ganglia has in the last larval stage a thick cell layer and, as in the other parts of the larval system, shows no sign of histolysis. Yet one hour after pupation this pair of ganglia completely disappears. An examination of the terminal nerves posterior to the seventh pair of ganglia shows the same structure as the terminal nerves behind the eighth pair of ganglia of the larva. Furthermore, the two pairs of lateral nerves of the eighth larval ganglia also disappear during this one-hour period. It was not possible to explain the cause of the disappearance of this eighth pair of ganglia. But, considering the lack of any sign of histolysis and considering the fact that the seventh pair of larval ganglia merges with the sixth by means of a shortening of their interconnection, it seems probable that the nerve elements of the eighth pair migrate forward and merge with those of the seventh. This hypothesis is further supported by the fact that the terminal ganglia of the one-hour pupa are somewhat larger than the seventh ganglia of the mature larva and by the fact that the terminal ganglia of the twelve-hour pupa has an exceedingly thick cortex of cells.

Seven pairs of abdominal ganglia occur in the six-hour pupa, but the twelve-hour pupa has only six pairs. The terminal pair of the twelve-hour pupa are formed by a fusion of the sixth and seventh pairs of the six-hour pupa and are quite long. There seems to be a concentration of cells in this last pair of ganglia, forming a thick layer around the scanty nerve fibers. These fused pairs of ganglia decrease in length from 320 microns in the twelve-hour pupa to 180 microns in the fifty-two-hour pupa. This occurs simultaneously with an elongation of the body up to the thirty-six-hour pupa, when the body begins to shorten slightly. There is a decrease in the lengths of both the ventral abdominal nerve cord and the body from the thirty-six-hour pupa to



the fifty-two-hour pupa. The terminal ganglia remain quite constant in length from the thirty-six-hour pupa (180 microns) to the emergence of the adult, when they become further shortened (150 microns).

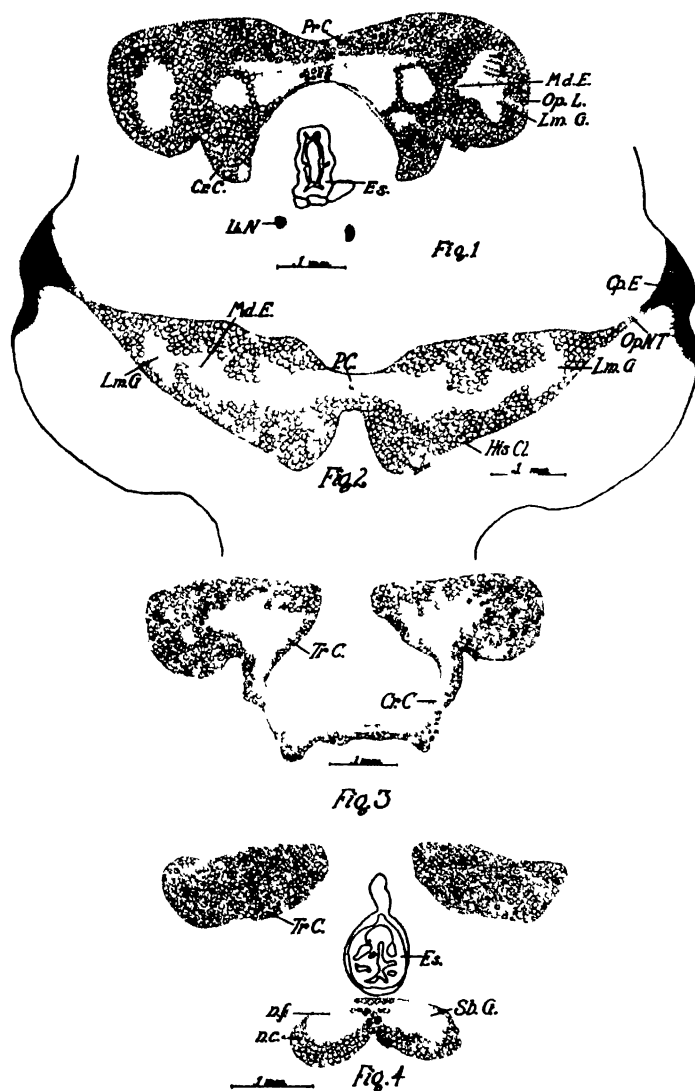
Mitosis was observed in the cells of all the pupal abdominal ganglia. The growth of these ganglia was almost imperceptible from the one-hour to the fifty-two-hour stage except that of the terminal ganglia, which enlarged due to fusion. There seemed to be a concentration of the nerve tissue and a shortening of the entire abdominal ganglionic chain from the six-hour pupa to the fifty-two-hour stage.

Histolysis took place *in situ* without phagocytosis, and the new cells seemed to be proliferated from the periphery of the ganglia.

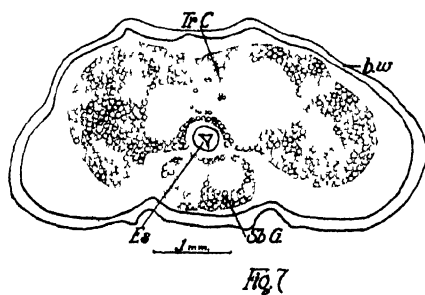
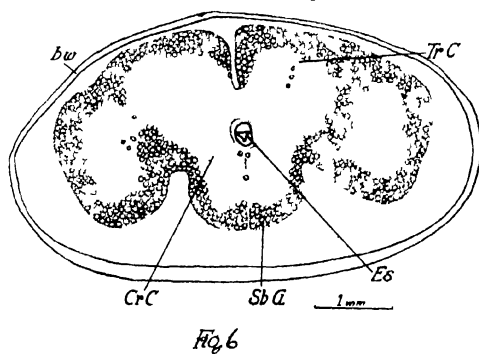
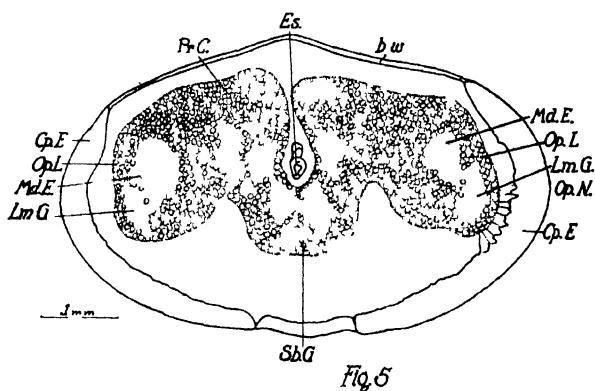
The abdominal ganglia of the imago were similar to those found in the fifty-two-hour pupa and retained the same histological characteristics.

#### ABBREVIATIONS USED IN PLATES

Ab. Gng.....	Abdominal Ganglion
6-7 Ab. Gng.....	6th-7th Abdominal Ganglion
Ad.....	Adipose tissue
An. C.....	Antennal Center of Brain
An. N.....	Antennal Nerve
b. w.....	Body wall
Cr. C.....	Crura Cerebri
Cp. E.....	Compound Eye
Deu. C.....	Deutocerebrum
Es.....	Esophagus
Es. Con.....	Esophageal Connective
Gng. Cl.....	Ganglionic Cell
His. Cl.....	Histolyzing Cell
Lb. N.....	Labial Nerve
Lg. Cs.....	Leg Case
Lg. N.....	Leg Nerve
Lm. G.....	Lamina Ganglionaris
Md. E.....	Medulla Externa
Mes. Th. Gng.....	Mesothoracic Ganglia
Met. Th. Gng.....	Metathoracic Ganglia
Mes-Met. Th. Gng.....	Meso-Metathoracic Ganglia
n. f.....	Nerve fibers
n. c.....	Nerve cells
Nv.....	Nerve
Nv. Tr.....	Nerve Tract
Or. J.....	Organ of Johnston
Op. L.....	Optic Lobe
Op. N.....	Optic Nerve
Op. N. T.....	Optic Nerve Trunk
P. C.....	Pons Cerebralis
Pd.....	Pedicle of Antenna
Pr. C.....	Protocerebrum
Pro. Th. Gng.....	Prothoracic Ganglia
Pr. Th.-Mes.-Met. Th. G.....	Between Prothoracic and Meso- Metathoracic Ganglia
Rec. Nv.....	Recurrent Nerve of Frontal Ganglion
Rd.....	Sensillia of Antennal Organ
Ret. N.....	Neuroglia Network
Sub. G.....	Suboesophageal Ganglion
S. Cls.....	Sensory cells
Seg. Nv.....	Segmental Nerve
Ter. Nvs.....	Terminal Nerves
Th. Con.....	Thoracic Connective
v. b. w.....	Ventral body wall
Wg. Nv.....	Wing Nerve



Sections through the brain of a mature larva of *Aedes dorsalis*. Figure 1. Protocerebrum, vertical section. 2. Protocerebrum, horizontal section. 3. Tritocerebrum, vertical section. 4. Tritocerebrum and subesophageal ganglion.



Vertical sections through the brain of a 24-hour pupa of *Aedes dorsalis*.  
Figure 5. Protocerebrum. 6-7. Tritocerebrum.

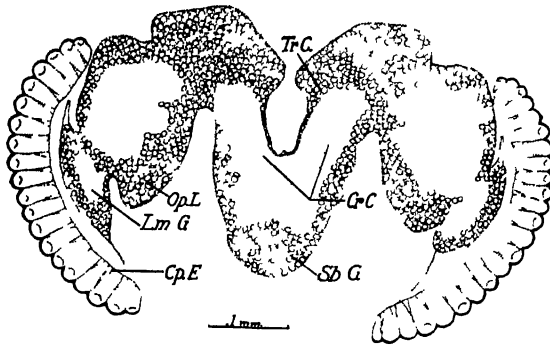


Fig 8

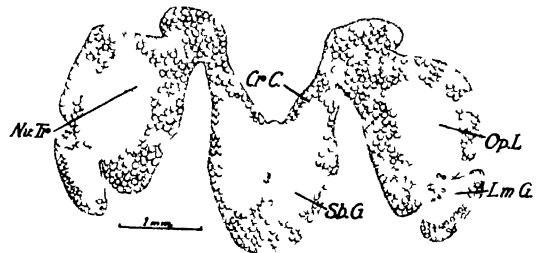


Fig 9

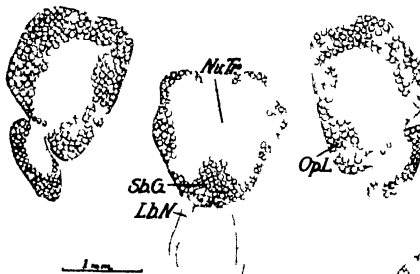


Fig.10

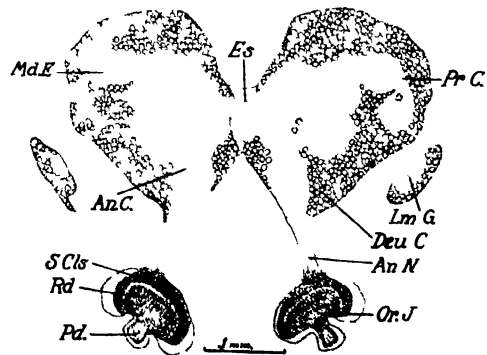
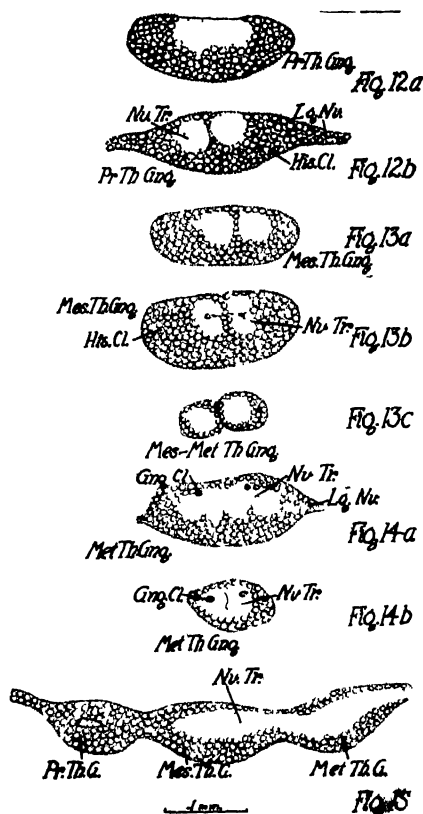
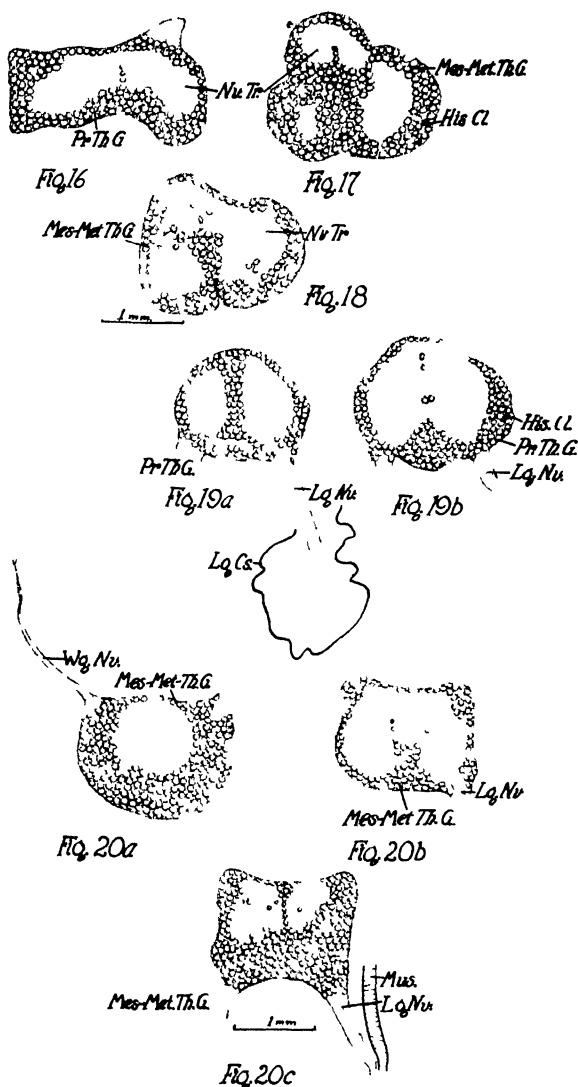


Fig 11

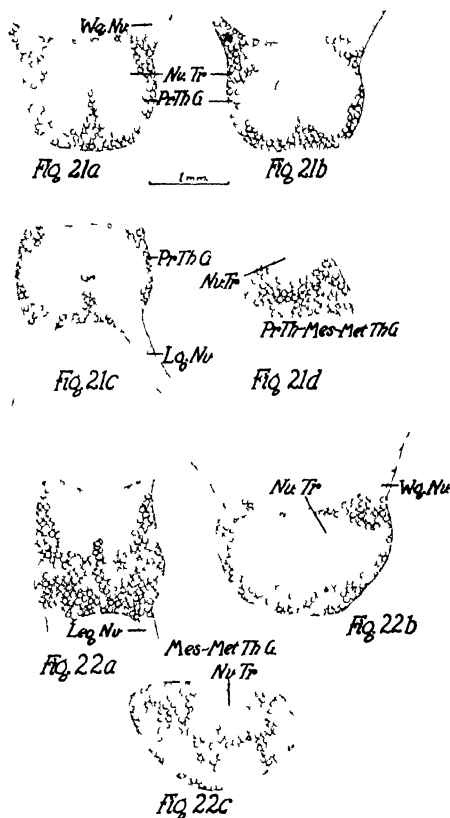
Vertical sections through the brain of the adult *Aedes dorsalis*. Figure 8. Protocerebrum 9 Tritocerebrum 10. Subesophageal ganglion. 11. Deutocerebrum



Vertical sections (except fig. 15, which is a longitudinal section) through the thoracic ganglia of the larva of *Aedes dorsalis*. Figure 12. Prothoracic ganglion (*b* posterior to *a*). 13. Mesothoracic ganglion (*b* and *c* posterior to *a*). 14. Metathoracic ganglion (*b* posterior to *a*). 15. Longitudinal section through the three thoracic ganglia.



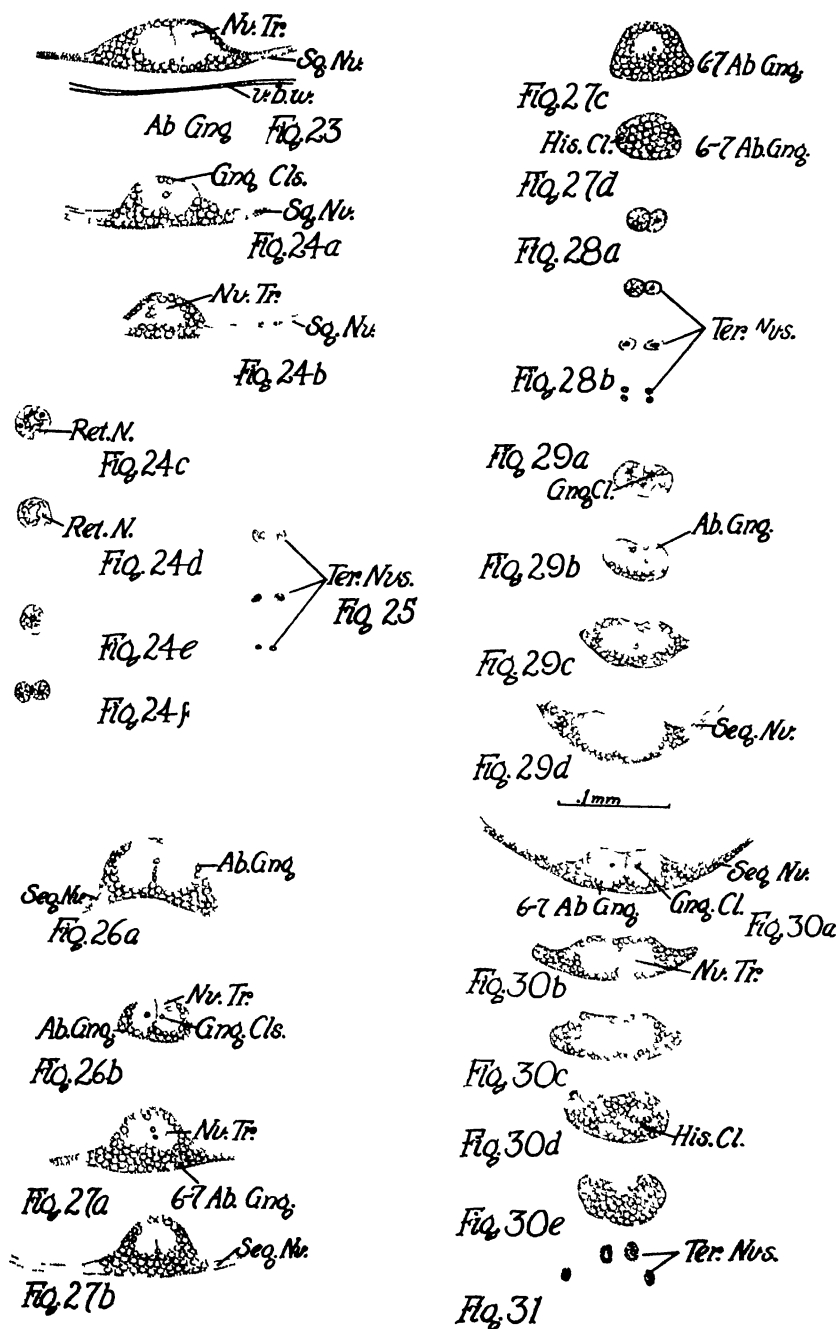
Vertical sections through the thoracic ganglia of the pupa of *Aedes dorsalis*. Figure 16. Prothoracic ganglion of early pupa. 17-18. Mesothoracic ganglion of early pupa (18 posterior to 17). 19. Prothoracic ganglion of late pupa (*b* posterior to *a*). 20. Meso-metathoracic ganglion of late pupa (*b* and *c* posterior to *a*).



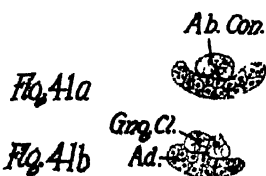
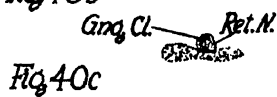
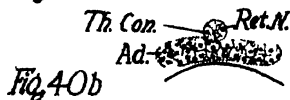
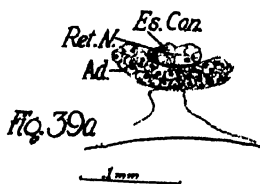
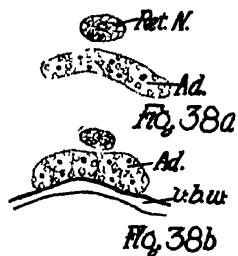
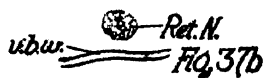
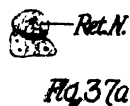
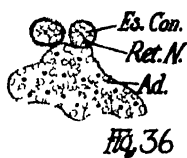
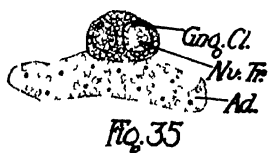
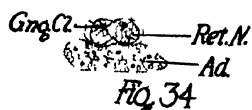
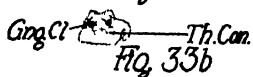
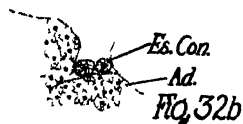
Vertical sections through the thoracic ganglia of the adult of *Aedes dorsalis*. Figure 21. Prothoracic ganglion (*b-d* posterior to *a*). 22. Meso-metathoracic ganglion (*b* and *c* posterior to *a*).

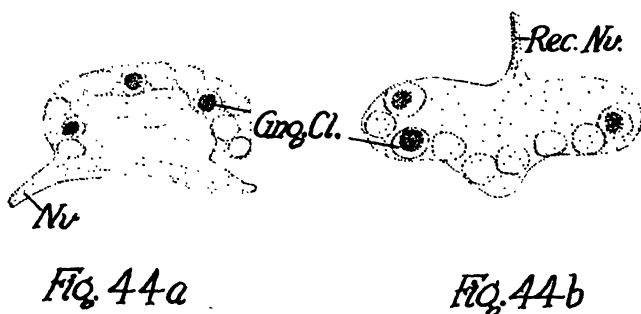
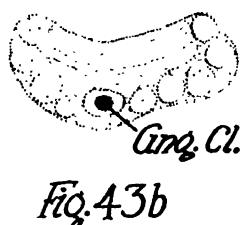
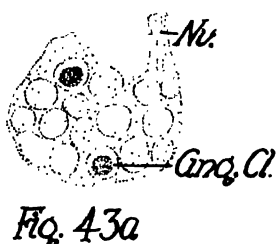
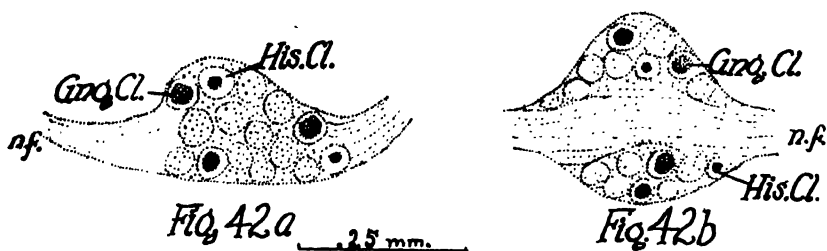
#### EXPLANATION OF PLATE VII

Vertical sections through the abdominal ganglia of *Aedes dorsalis*. Figure 23. Typical abdominal ganglion of larva. 24. Terminal ganglion of larva (*b-f* posterior to *a*). 25. Terminal nerves of larva. 26. Typical abdominal ganglion of 24-hour pupa (*b* posterior to *a*). 27. Terminal abdominal ganglion of pupa (*b-d* posterior to *a*). 28. Terminal nerves of pupa (*b* posterior to *a*). 29. Typical abdominal ganglion of adult (*b-d* posterior to *a*). 30. Terminal ganglia of adult (*b-e* posterior to *a*). 31. Terminal nerves of adult.









Vertical sections through the connectives of *Aedes dorsalis*. Figure 42. Frontal ganglion of larva (b posterior to a). 43. Frontal ganglion of pupa (b posterior to a). 44. Frontal ganglion of adult (b posterior to a.)

#### EXPLANATION OF PLATE VIII

Vertical sections through the connectives of *Aedes dorsalis*. Figure 32. Esophageal connectives of larva (b posterior to a). 33. Thoracic connectives of larva (b posterior to a). 34. Abdominal connectives of larva. 35. Beginning of an abdominal ganglion of larva. 36. Esophageal connectives of pupa. 37. Thoracic connectives of pupa (b posterior to a). 38. Abdominal connectives of pupa (b posterior to a). 39. Esophageal connectives of adult (b posterior to a). 40. Thoracic connectives of adult (b and c posterior to a). 41. Abdominal connectives of adult (b posterior to a).

## DISCUSSION

The development of the larval brain into the pupal brain consists mainly of growth. The brain becomes approximately twice as large and occupies two-thirds of the cranial cavity of the pupa. It becomes more compact, the crura cerebri shorten, and the suboesophageal ganglia move forward from the neck region and become fused with the brain proper. The compound eyes develop simultaneously with the expanding optic lobes.

With few exceptions cell divisions occur mainly in the periphery of the cortex of the brain. The new cells seem to be proliferated from the peripheral portions of the brain, and histolysis takes place *in situ* without phagocytosis.

The frontal ganglion exhibits the same histological structure in each stage from the larva to adult, but changes slightly in shape.

The three pairs of thoracic ganglia of the larva are reduced to two pairs in the pupa by the fusion of the meso- and metathoracic pairs. This arrangement persists through the pupal stages into the adult. Growth occurs mainly in the fused, posterior pair.

There seems to be a forward concentration of the nerve tissues which accompanies the growth of the ganglia. With few exceptions cell division was found to occur mostly in the periphery of the ganglia. Histolysis occurred *in situ* without phagocytosis, and the new cells seemed to proliferate from the peripheral portions of the ganglia.

There are eight abdominal ganglia in the larval stage. Those of the mature larva are slightly larger than those of the immature larva. The terminal pair of ganglia, lateral nerves, and connectives disappear during pupation. There are seven pairs of ganglia in the one-hour and six-hour pupae, but there is a fusion of the sixth and seventh pairs in the twelve-hour pupa. This fusion results in six pairs of ganglia, and the larger terminal pair exhibits thick cell cortices.

The body elongates up to the thirty-six-hour pupa, when it shortens slightly. At the same time the pairs of abdominal ganglia shorten and seem to move forward as a result of a concentration of the nerve tissue. This continues from the six-hour pupa to the adult.

Cell divisions occur in the cells of the mature larva and throughout the pupal stages. The growth of the abdominal ganglia is imperceptible except for that of the fused pair of terminal ganglia. Histolysis occurs *in situ* without phagocytosis, and the new cells seem to be proliferated in the same manner as in the other ganglia.

## CONCLUSIONS

1. Histolysis of the nervous tissue takes place *in situ* without phagocytosis. The new cells seem to proliferate from the periphery of the ganglia. Thus *Aedes dorsalis* is characteristic of those insects in which there is histolysis of the nervous tissue *in situ* without phagocytosis.

2. There is a shortening of connectives and a forward concentration of the nerve tissue which results in the fusion of the brain and suboesophageal ganglia, the meso- and metathoracic ganglia, and the sixth and seventh abdominal ganglia. This fusion occurs simultaneously

with an elongation of the body to the thirty-six-hour pupa and a subsequent shortening of the same to the fifty-two-hour pupa.

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### THE C. V. RILEY CENTENNIAL EXHIBITION, MUSEUM OF NATIONAL EXPANSION, ST. LOUIS

Entomologists will be interested in hearing of our plans for celebrating the centennial of the birth of C. V. Riley. The Jefferson National Expansion Memorial is a national historic site established to commemorate the westward movement of the American people. Because Riley made outstanding contributions to the successful advance of agriculture into the West, and also because he did some of his work actually within the area of the Memorial, the National Park Service is arranging a special Riley centennial exhibition to be held in the Museum of National Expansion in St. Louis.

The exhibition will outline Riley's career, point out his accomplishments as an artist and his productivity as a scientific writer, and will illustrate his work on two insects important in western agriculture—the Rocky Mountain locust and the cottony cushion scale. It will be opened on the evening of September 22 with a public meeting sponsored jointly by the St. Louis Academy of Science and the Jefferson National Expansion Memorial, the program featuring an illustrated lecture on Riley and his work by Dr. E. P. Meiners of St. Louis. The exhibition will remain on view through October 24. Material for display is being generously loaned by the American Museum of Natural History (Dr. Frank E. Lutz), the University of California (Dr. E. O. Essig), and the Montana State College (Dr. Harlow B. Mills).

JULIAN C. SPOTTS, *Superintendent,*  
*Jefferson National Expansion Memorial.*

# A NEW GENUS—STONEANA—AND THREE NEW SPECIES OF MEXICAN LEAFHOPPERS

(Homoptera: Cicadellidae)

DWIGHT M. DeLONG,

Ohio State University,  
Columbus, Ohio

In 1936, Dr. E. D. Ball in company with Mr. W. E. Stone who is with the U. S. Bureau of Entomology and Plant Quarantine stationed in Mexico City, collected several species of Mexican leafhoppers. A very interesting species collected at that time was apparently not described and does not belong to a known genus. Dr. Ball had, therefore, planned before becoming seriously ill to name the genus for Mr. Stone and the species for Mrs. Stone and their daughter, both of whom have the given name Martha. Since Dr. Ball has not recovered and will probably not again be able to carry on his taxonomic studies, and since I have been working over a large amount of Mexican material, I am happy to name both the genus and species as he had planned and also in honor of my good friends, the three members of the Stone family.

## Genus *Stoneana* nov.

Closely related to *Aligia*. The vertex is conspicuously depressed just behind the margin, causing the apex, in lateral view, to appear as a dorsally produced ridge. The margin is not sharp, the face extending to the top of the marginal ridge. The vertex is short and broad as in *Aligia*. The elytra contains the two cross veins and many supernumerary cross veins especially on the clavus, costa and first anteapical cell.

\*Genotype *Stoneana marthae*, n. sp.

## *Stoneana marthae*, new species

A white to pale yellow species with orange and black markings. Length 4.5 to 5 mm.

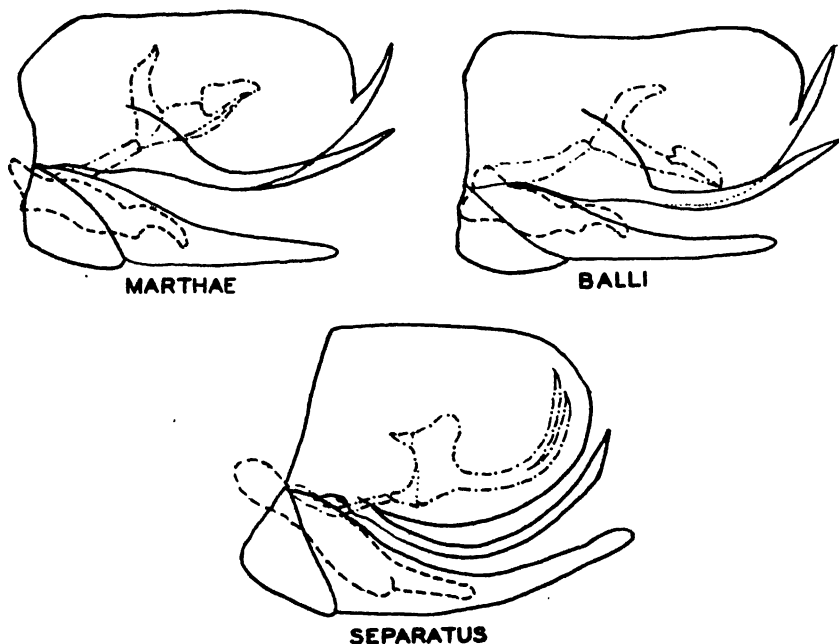
Vertex short, rather broadly ~~rounded~~ produced, and appearing almost parallel-margined, twice as broad as median length.

*Color*.—White to yellow, vertex with a pair of proximal angular black spots at apex, and a smaller one next to the eye on either side just below ocellus. ~~Disc~~ usually orange. Pronotum mostly orange with a median longitudinal white stripe, an oblique spot on either side, and a white spot behind each eye near lateral margin. Pronotum pale with darker basal angles and a black angular spot on either side of apex. Elytra white with orange veins, crossveins and orange blotches, giving the elytra the appearance of being spotted with white. Face white.

*Genitalia*.—Last ventral segment of female with produced lateral angles, between which the posterior margin is broadly and rather deeply concavely excavated on either side of a broad medially pro-

duced tooth which is slightly notched at apex. Male valve broad and rounded, plates long, triangular. Aedeagus L-shaped with a basal erect portion and the thickest and largest portion extending caudally. The apical half is sloped upwards on the ventral side to form a narrow blunt apex, just anterior to which is a short angled wing-like projection on either side. The ventral portion of the pygofer gives rise to a long black spine at about half its length which extends to the tip of pygofer. Also, a short black pointed spine arises on the ventral caudal margin of the pygofer and extends a little farther than the basal spines.

Holotype male, allotype female and male and female paratypes collected on the Cuernavaca-Acapulco Road, August 29, 1936, by Ball and Stone. Holotype male, allotype female and male and female paratypes in Ball's collection. Paratype male and female in author's collection.



*Stoneana balli*, new species

In form and general appearance resembling *marthae*, but with darker coloration and slightly different male genitalia. Length 4.5 mm.

Vertex broadly rounded, less than twice as wide between eyes at base as median length.

*Color*.—Vertex pale yellow, with a broad, angular orange spot on either side on basal two-thirds. Each spot extends from eye to middle in front and tapers to about the middle on either side at base having a white spot at middle and an angular white spot next

the base of either eye. Margin with a large angular black spot on either side of apex. A small round black spot just above each ocellus and a pair of black spots next to each eye. The ventral spot below the margin is the larger. Face yellow with pale brown arcs on either side of middle. Pronotum dark brown with five pale spots across middle. Scutellum brownish with apical third paler, a black angular spot on either side of apex. Elytra whitish subhyaline, veins dark brown and with paler brown mottling on clavus and disc.

*Genitalia*.—Male valve rather short, broad, and rounded at apex. Plates elongate, triangular. Aedeagus L-shaped as in *marthae* with a basal erect portion and a thicker caudal portion which bears a rather conspicuous wing-like process on either side of the apical half just before the blunt, rounded apex. As in the case of *marthae*, a long black spine arises at about the middle of the pygofer on ventral margin and extends to its apex. Also a short black spine arises on the apical ventral portion of the pygofer and is directed almost dorsally. The apical spine in this species is heavier than the same spine in *marthae*.

Holotype male and paratype male collected on the Cuernavaca-Acapulco Road, August 23 and 24, by Ball and Stone. Paratype males collected at Jacala, Hgo., Mexico, August 13, 1936, by Dr. E. D. Ball. Holotype and paratypes in Ball collection. Paratype male in author's collection.

#### *Stoneana separatus*, new species

Resembling *balli* in form and color but with distinct male genitalia. Length 5 mm.

Vertex more produced than in *balli*, but rounded at apex, more than half as long at middle as basal width between the eyes.

*Color*.—Vertex white with a broad orange spot on either side between anterior margins of the eyes which tapers to a narrow spot at base. Margin with a large black spot on either side of apex, a smaller spot just above each ocellus, and a black spot next to eye just below each ocellus. Face pale with light brown arcs and coloration on either side of middle. Pronotum orange brown with four large white spots across middle and a longitudinal pale stripe. Scutellum pale with brownish basal angles and tinted with orange on middle and a black angular spot on either side of apex. Elytra white with dark brown veins and brownish mottling especially on clavus.

*Genitalia*.—Male valve very short, almost transverse. Plates elongate, triangular, rather broad at base, tapered to narrow blunt apices. Aedeagus with a rather broad basal portion which appears square and extends dorsally. At the base of this portion a narrow process extends caudally then curves dorsally, the apical half of which, extending from about the beginning of the curved portion, is cleft, forming two slightly separated pieces. The pygofer bears only one spine which arises near the base on the ventral margin and extends almost to the apex of pygofer.

Holotype male and paratype male collected at Yetia, Gro., Mexico, August 11, 1930 (M. F. 1756) by J. Parra. Holotype and paratype in author's collection.

# A NEW PHILIPPINE NIPPONONYSSON WITH REMARKS ON THE AFFINITIES OF THE GENUS

(Hymenoptera: Nyssonidae)

KARL V. KROMBEIN,

Bureau of Entomology and Plant Quarantine,  
United States Department of Agriculture

The description of the following new *Nippononysson* is published at this time so that a name will be available for use in the notes which follow on the affinities of the genus.

## *Nippononysson adiaphilus*,<sup>1</sup> new species

*Type*.—Female, Samar Island, Philippines (C. F. Baker) (United States National Museum, Type No. 56316).

*Female*.—Length 8 mm. Black, with the following ferruginous: Mandible medially, tegula, fore tibia on outer side, middle tibia on outer side at base, hind femur and tibia except at apex, all tarsi, and first three abdominal segments. Pubescence moderately abundant, short, appressed, and silvery. Wings subhyaline, densely hairy; stigma dark brown, nervures lighter, tending toward ferruginous; venation similar to that of *rufopictus*, except that the cubital vein of the forewing is present beyond the second submarginal cell only as a short stub whereas this vein extends to the wing margin in *rufopictus*.

Head shining; clypeus transversely tumid distally, apical third impunctate and with a narrow, transverse flange apically, the margin of which is not noticeably emarginate laterally as it is in *rufopictus*; front with a very short, low, median, longitudinal keel just above and between antennal scrobes, and with fine, moderately close punctures; ocelli closely placed in a triangle, postocellar distance about half ocellular distance; vertex less closely but as finely punctured as the front.

Thorax subopaque; pronotal disk with scattered fine punctures anteriorly, posteriorly with a transverse row of fairly large, shallow pits; lateral surface of pronotum with oblique carinae above, and with longitudinal carinae below; mesoscutum with moderately numerous, fine punctures among which are scattered some larger, sparser punctures; mesoscutal laminae raised slightly above level of rest of mesoscutum, truncate and declivous posteriorly and extending slightly beyond remainder of mesoscutum; scutellum tumid, posteriorly with a broad, deep, longitudinal groove so that it appears bilobate, anteriorly with close, fine punctures, posteriorly with subcontiguous pits; postscutellum less tumid than scutellum, and with irregular rugae; mesopleuron anterior to epicnemial furrow smooth, except for piliferous micropunctures, posteriorly with large, irregular reticulations;

<sup>1</sup>Derivation: *adia*, Greek, *adeia*, freedom, etc.; *philus*, Greek, *phileo*, to love. In allusion to the country of its origin, rather than to its possible habits.



metapleuron smooth except for piliferous micropunctures; dorsum of propodeum irregularly reticulate, with enclosed area indistinctly set off, sides convergent toward rear and broadly rounded posteriorly, median length about three-fourths basal width; posterior surface of propodeum with irregular reticulations which are same size as those on anterior half of dorsal surface; lateral surface of propodeum smooth on anterior half, and with longitudinal to oblique carinae posteriorly.

Abdomen shining; first tergum with small, scattered punctures, except for the postero-lateral concentration of close punctures; second tergum with median punctures sparse, the density becoming gradually more concentrated laterad until, from lateral fifth to extreme side the punctures are separated by a puncture's width or less; third and fourth terga largely telescoped beneath second, but apparently the arrangement of punctures is similar to that of the second; fifth tergite with punctures regularly spaced with a distance of two or three puncture widths between most of them; sixth tergum laterally and basally with punctures slightly more concentrated than on fifth, pygidial ridges sharp and reflexed on apical half of segment, posterior half of pygidium impunctate, apical margin narrowly rounded; first sternum with paired median carinae sharp, well defined, much less divergent posteriorly than in *rufopictus*, not enclosing a short, median carina on apical sixth as in *rufopictus*, free margin of carinae sinuate as viewed from side, remainder of sternum delicately, finely, and irregularly reticulate; second sternum extremely tumid medially, in profile anterior and posterior slopes meeting at almost a right angle, punctures medially and anteriorly sparse, gradually increasing in concentration posteriorly and laterally until they are separated by a puncture's width or less; third and fourth sterna not visible; fifth sternum with moderately close punctures on posterior half; sixth sternum impunctate medially, laterally with moderately close punctures.

*Male*.—Unknown.

*Remarks*.—The genus was known previously only from the genotypic species, *Nippononysson rufopictus* Yasumatsu and Maidl<sup>2</sup>, from Kyûshû, Japan, and Amami-Oshima, Rykûyû Islands.

The following couplet will serve to separate *adiaphilus* from *rufopictus* until material of the latter species is at hand. The key characters in parentheses have been taken from the illustrations accompanying the original description of *rufopictus*; the other characters of *rufopictus* are from the original description.

Paired median carinae of first abdominal sternum very slightly divergent posteriorly and not enclosing a short, median carina on apical sixth; first three abdominal segments ferruginous; fore tibia on outer side, middle tibia on outer side at base, hind femur and tibia except at apex, and all tarsi ferruginous; postocellar distance about half the ocellocular distance; apical margin of clypeus not noticeably emarginate laterally; cubital vein in forewing extending only a short distance beyond second submarginal cell,

*adiaphilus*

<sup>2</sup>Yasumatsu and Maidl. Festschr. 60 Geburtst. E. Strand, i, pp. 501-4, pl. 13; 1936.

Paired median carinae of first abdominal sternum noticeably divergent posteriorly and enclosing a short, median carina on apical sixth; first two abdominal segments ferruginous; legs black; (postocellar distance subequal to ocellular distance; apical margin of clypeus noticeably emarginate laterally; cubital vein in forewing extending to wing margin).....*rufopictus*

## GENERIC AFFINITIES OF NIPPONONYSSON

The genus *Nippononysson* was assigned originally<sup>2</sup> to the Nyssoninae with the notation that it was close to *Nysson* and *Hyponysson*. The characters of the hind femur and tibia and front were omitted so that it was impossible for Pate<sup>2</sup> to assign it to a definite position in his proposed classification of the Nyssonini. However, Pate assumed that the hind femur and tibia were simple and unarmed and that the frontal keel was lacking owing to the fact that the figures and failure to note any distinguishing features of these members in the original description implied the lack of modification of these structures. An examination of the Philippine *adiaphilus* shows that Pate was correct in his assumption though there is a short median keel on the front above the antennae.

Pate's graphical representation of the evolutionary trends of the Nyssonini (p. 124) shows that *Foxia* lacks a median keel on the front, but his generic diagnosis (p. 144) indicates that the front may have a short keel or tubercle. Several females of *Foxia pacifica* Ashmead in the United States National Museum collection have such a short frontal keel and it is similar in length and development to that of *adiaphilus*.

Pate's tribal diagnosis (p. 121) indicates that the dorsal caudolateral angles of the propodeum are unarmed in *Nippononysson* (in contrast to all other Nyssonini) and that the forewing of this genus has only two submarginal cells and a larger stigma than normally. The Philippine specimen agrees with *rufopictus* in these respects. Pate states also that the epicnemial furrow (omaulus) is generally obsolete in the Nyssonini, but this is very well developed in *Nippononysson*. The genus agrees with the other tribal characters.

However, superficially the genus bears a much stronger resemblance to certain of the genera of the Gorytini than it does to any of the Nyssonini and it may be of interest to examine it in the light of this resemblance. The chief characters which would place it with the Gorytini are the unarmed propodeum, large stigma, and type of integument. The size of the stigma is subject to some variation among the various groups of Nyssonini (see Pate's figures 2 and 3 of *Melanysson* (*Melanysson*) and *Melanysson* (*Huachuca*)), and is hardly a valid reason for excluding *Nippononysson* from the Nyssonini.

In my opinion the lack of teeth or spines at the dorsal caudolateral angles of the propodeum may be associated with the comparative thickness and sculpture of the integument. All Nyssonini, except *Nippononysson*, have a very thick, coarsely sculptured integument which presumably gives the nyssonine considerable protection from the aculeates upon which it is parasitic. In *Nippononysson*, however, the integument of the head and abdomen is very much thinner, and minutely and shallowly punctate, and that of the thorax is not much thicker or

<sup>2</sup>Pate, V. S. L. Trans. Amer. Ent. Soc., lxiv, pp. 117-190, pls. 7-8 1938.

more coarsely sculptured than that of the nonparasitic Gorytini, e. g., *Hoplisoides* Gribodo and *Gorytes* Latreille. This may possibly indicate that *Nippononysson* is not a parasite, or has not become so perfectly adapted to parasitic life as the other nyssonines. However, it does not seem practical to make parasitic or nonparasitic habits a criterion for determining whether a genus belongs to one tribe or another.

The fact that the meso- and metasternal characters of *Nippononysson* are similar to those of the Nyssonini and dissimilar to those of the Gorytini is a much more valid reason for including it in the former tribe rather than the latter, and, I think, a much better indication of its true affinities than any of the characters mentioned in the two paragraphs immediately above.

The simple hind femur and tibia and poorly developed frontal keel (as in *Foxia* Ashmead and *Hyponysson* Cresson) indicate the generalized condition of *Nippononysson*. The thinner, more finely sculptured integument, lack of propodeal spines or teeth, and very large stigma seem to indicate that *Nippononysson* belongs much closer to the primitive nyssonine stock than any of the existing genera. This theory would be strengthened by the possible future discovery that the species are not parasitic as are certain of the other Nyssonini.

STUDIES IN THE GENETICS OF DROSOPHILA. III. THE DROSOPHILIDAE OF THE SOUTHWEST. Directed by J. T. PATTERSON. Pages 1-327, 66 figures plus 25 plates (10 in color), 7 x 10 inches, paper bound. The University of Texas Publication, No. 4313. Published by THE UNIVERSITY OF TEXAS, Austin, Texas. 1943. Price, \$2.50.

The first two publications in this series dealt primarily with chromosomal aberrations (Part I, 1940), and gene variation and evolution (Part II, 1942); the present publication is a general account of the various species of *Drosophila* which occur in southwestern United States and northern Mexico. This account is divided into three sections: I—The Drosophilidae of the Southwest, by J. T. Patterson; II—Geographical Distribution of Species of the Genus *Drosophila* in the United States and Mexico, by J. T. Patterson and R. P. Wagner; III—Analysis of the Metaphase and Salivary Chromosome Morphology Within the Genus *Drosophila*, by Linda T. Wharton.

Part I (pp. 7-216) is concerned primarily with the systematics of the family Drosophilidae, but contains a short section on methods of collecting *Drosophila*, and a report of field studies on fluctuations in *Drosophila* populations. The systematic section contains detailed descriptions of the more than a hundred species of Drosophilidae (mostly in the genus *Drosophila*), of which 24 are described as new; a key to 111 North American species of *Drosophila* (not including a number of species described by Duda in 1925, nor the new forms described in this publication), 11 tables summarizing the collection records of 905,047 specimens, and some excellent illustrations. There are 65 figures of line drawings, illustrating chiefly the internal reproductive systems of both sexes, the egg, and the puparium of most of the species, and ten colored plates illustrating 73 forms (drawn from living specimens).

Part II (pp. 217-281) is a comprehensive treatment of the geographical distribution of these flies, and contains 16 distribution maps and 30 tables. Part III (pp. 282-319) represents a continuation of Dr. Wharton's study on the chromosomes of the *repleta* group, which was published last year in Publication II of this series; it contains 15 plates of chromosome figures.

In looking over this publication, we are particularly impressed by the thoroughness with which the study was made, and the values to science generally to be derived from cooperative effort in studies of this sort. Entomologists may well emulate the Texas group responsible for this series of publications.—D. J. B.

## MEMBRACIDAE OF GUATEMALA

W. D. FUNKHOUSER,  
University of Kentucky,  
Lexington, Ky.

As a result of a rather intensive and very successful collecting trip in Guatemala in 1942, it has been possible not only to recognize practically all of the species of Membracidae which have been reported from that country, but to add a large number of new locality records and to describe sixteen new species.

Since no check-list or catalogue of the Guatemalan Membracidae has ever been published, we are here recording for each species the reference to the original description, any changes in synonymy and the locality records. This list includes all of the species of Membracidae which have been reported from Guatemala in the literature of the family.

### Subfamily **Membracinae**

#### **Bolbonota cuneata** Fowler

1894. *Bolbonota cuneata* Fowler, B. C. A.,<sup>1</sup> p. 17; Tab. 2, figs. 4, 4a, 4b.

San Isidro (Champion, 1894).

#### **Bolbonota inconspicua** Fowler

1894. *Bolbonota inconspicua* Fowler, B. C. A., p. 18; Tab. 2, figs. 5, 5a.

El Tumbador (Champion, 1894); Chimaltenango (W. D. F., 1942).

#### **Bolbonota insignis** Fowler

1894. *Bolbonota insignis* Fowler, B. C. A., p. 17; Tab. 2, figs. 2, 2a, 3.

Vera Paz (Champion, 1894).

#### **Bolbonota pictipennis** Fairmaire

1846. *Bolbonota pictipennis* Fairmaire, Revue Membracides, p. 258.

1851. *Tetraplatys atomarius* Walker, List Homoptera British Museum, p. 510.

Rio Naranjo, Las Mercedes, Cerro Zunil, Vera Paz (Champion, 1894); Zarazoga (W. D. F., 1942).

#### **Bolbonota atitla** sp. nov.

(Figure 1)

Large, globose, corrugated, shining brown, coarsely punctate, not pubescent; pronotum swollen, arcuate, dorsal margin irregular, two deep depressions on each side, suddenly depressed before posterior process; posterior process almost reaching tips of tegmina; tegmina black with yellow spots; head and legs strongly foliaceous; under surface extending far below tegmina. This species is nearest to *B.*

<sup>1</sup>Biologia Centrali-Americana. Insecta. Rhynchota. Hemiptera-Homoptera, Vol. II, Part I.

*corrugata* Fowler, but is larger and has the pronotal convolutions in a different arrangement.

Head foliaceous, quadrangular, wider than long, finely punctate, sparingly pubescent, roughly sculptured; base regularly arcuate; eyes gray; ocelli conspicuous, white, glassy, farther from each other than from the eyes and situated slightly above a line drawn through centers of eyes; inferior margins of genae short and rounded; clypeus very large, foliaceous, extending for two-thirds its length below inferior margins of genae and projecting laterad beyond the genae in sharp angles, tip pointed.

Pronotum bright reddish-brown, coarsely punctate, not pubescent; roughly sculptured and corrugated with ridges and depressions; three rounded ridges on each side separated by deep fossae; dorsal margin arcuate and irregular, suddenly depressed before posterior process; metopidium sloping above the head, wider than high, with two longitudinal ridges on each side; median carina strongly percurrent; humeral angles heavy, blunt, triangular; posterior process short, heavy, depressed at tip, not quite reaching tips of tegmina.

Tegmina entirely exposed, broad, black with irregular yellow spots, opaque; base widely coriaceous and punctate; five apical and four discoidal cells; apical limbus broad and wrinkled.

Under surface of body swollen, brown; first two pairs of tibiae very foliaceous; hind tibiae swollen at distal end; femora and tibiae brown; tarsi yellow.

Length from front of head to tips of tegmina 4 mm.; width between humeral angles 3.2 mm.

Described from a single female taken at Lake Atitlan, Guatemala, on February 18, 1942. Type in author's collection.

#### ***Enchenopa quadricolor* Walker**

1858. *Enchenopa quadricolor* Walker, *Insecta Saundersiana*, p. 60.

1858. *Enchenopa subangulata* Walker, *Ins. Saund.*, p. 61.

1858. *Enchenopa exelsior* Walker, *Ins. Saund.*, p. 61.

1858. *Enchenopa humilior* Walker, *Ins. Saund.*, p. 62.

1858. *Enchenopa curvicornis* Walker, *Ins. Saund.*, p. 62.

Guatemala City (Champion, 1894); (W. D. F., 1942).

#### ***Enchenopa bifusifera* Walker**

1858. *Enchenopa bifusifera* Walker, *List Hom. B. M. Suppl.*, p. 125.

Chichicastenango (W. D. F., 1942).

#### ***Enchenopa ansera* sp. nov.**

(Figure 2)

Jet black with two white spots on dorsal margin; finely punctate, not pubescent; pronotal horn at first porrect and then strongly curved forward; lateral carinae reaching margins of pronotum; posterior process reaching just beyond internal angle of tegmen; tegmina black; head and legs foliaceous; under surface and legs black, tarsi white.

Head foliaceous, quadrate, black, finely punctate, not pubescent; base straight; eyes black with white border; ocelli conspicuous, pearly,

shining, twice as far from each other as from the eyes and situated about on a line drawn through centers of eyes; inferior margins of genae slightly sinuate; clypeus very large, foliaceous, extending for two-thirds its length below inferior margins of genae, tip broadly truncate.

Pronotum black, finely punctate, not pubescent; two white spots on dorsal margin; pronotal horn long, heavy, blunt, strongly curved forward, strong sharp dorsal and lateral carinae, the lateral carinae equidistant from the dorsal and ventral margins of the horn and extending to margins of pronotum, both dorsal and ventral margins of horn foliaceous; metopidium sloping forward from head, higher than wide; humeral angles short, triangular and blunt; posterior process slender, very acuminate, extending just beyond internal angles of tegmina.

Tegmina entirely exposed; black and opaque; five apical and three discoidal cells; apical limbus broad and wrinkled.

Under surface of body black; femora and tibiae black; tarsi white; front and middle tibiae very foliaceous.

Length from front of head to tips of tegmina 4.5 mm.; length from eyes to tip of pronotal horn 3 mm.; width between humeral angles 1.8 mm.

Described from a single male collected on the shore of Lake Atitlan, Guatemala, on February 25, 1942. Type in author's collection.

#### ***Enchophyllum albidum* Fowler**

1894. *Enchophyllum albidum* Fowler, B. C. A., p. 7; Tab. 1, figs. 8, 8a.

San Geronimo (Champion, 1894).

#### ***Enchophyllum dubium* Fowler**

1894. *Enchophyllum dubium* Fowler, B. C. A., p. 8, Tab. 1, figs. 9, 9a, 9b.

Teleman, Vera Paz (Champion, 1894).

#### ***Enchophyllum melaleucum* Walker**

1858. *Enchenopa melaleuca* Walker, Ins. Saund., p. 59.

1894. *Enchophyllum melaleucum* Fowler, B. C. A., p. 7; Tab. 1, figs. 7, 7a, 7b.

Sabo, Cerro Zunil (Champion, 1894).

#### ***Erechtia sallaei* Fowler**

1894. *Tropidoscyta sallaei* Fowler, B. C. A., p. 13; Tab. 1, figs. 19, 19a.

1903. *Bolbonota sallaei* Buckton, Monograph of Membracidae, p. 52.

1928. *Erechtia sallaei* Goding, Jour. N. Y. Ent. Soc., 36: 219.

San Geronimo (Champion, 1894).

#### ***Hypsoprora coronata* Fabricius**

1803. *Membracis coronata* Fabricius, Syst. Rhyng., p. 14.

1851. *Pterygia varia* Walker, List Hom. B. M., p. 502.

1859. *Pterygia coronata* Dohrn, Catalogue of Hemiptera, p. 77.

1869. *Aechmopha coronata* Stål, Bid. Memb. Kan., p. 279.

1894. *Hypsoprora coronata* Fowler, B. C. A., p. 26; Tab. 2, figs. 17, 17a, 17b.

Chicam, Vera Paz (Champion, 1894).

***Hypsoprora nigerrima* Fowler**

1894. *Hypsoprora nigerrima* Fowler, B. C. A., p. 25; Tab. 2, figs. 14, 14a.  
El Tumbador (Champion, 1894).

***Membracis foliata* Linnaeus**

1705. Figure, Merian, Ins. Surinam, Pl. 5.  
1767. *Cicada foliata* Linnaeus, Syst. Nat., 2: 705.  
1775. *Membracis foliata* Fabricius, Syst. Ent., 2: 675.  
1780. *Cicada maculifolia* Stoll, Cigal., p. 17; Pl. 1, fig. 2.  
1787. *Membracis flaveola* Fabricius, Mant. Ins., 2: 262.  
1851. *Membracis celsa* Walker, List Hom. B. M., p. 475.  
1851. *Membracis surgens* Walker, List Hom. B. M., p. 475.  
1851. *Membracis expansa* Walker, List Hom. B. M., p. 475.  
1858. *Membracis flexa* Walker, Ins. Saund., p. 58.  
1920. *Membracis jessica* Goding, Membracidae of Ecuador, p. 34, fig. 1.

Guatemala (Salle).

***Membracis mexicana* Guerin**

1838. *Membracis mexicana* Guerin, Icon. Reg. Anim., p. 364; Pl. 59, fig. 1.  
1846. *Membracis stolidia* Fairmaire, Rev. Memb., p. 248.  
1858. *Membracis sex-maculata* Walker, Ins. Saund., p. 59.  
1903. *Phyllotropis suffusa* Buckton, Mon. Memb., p. 38; Pl. 3, figs. 1, 1a.  
1903. *Phyllotropis mexicana* Buckton, Mon. Memb., p. 41.

San Joaquin, Duenas, San Geronimo, Vera Paz, Mirandilla, San Isidro (Champion, 1894); Guatemala City (W. D. F., 1942); Guatemala (Funkhouser collection, collector unknown).

***Philya minor* Fowler**

1894. *Philya minor* Fowler, B. C. A., p. 22; Tab. 2, figs. 9, 9a, 9b.  
Cerro Zunil (Champion, 1894).

***Notocera bituberculata* Fowler**

1894. *Pterygia bituberculata* Fowler, B. C. A., p. 24; Tab. 2, figs. 13, 13a.  
1928. *Notocera bituberculata* Goding, Jour. N. Y. Ent. Soc., 36: 232.

San Juan, Chacoj, El Reposo (Champion, 1894).

***Notocera cerviceps* Fowler**

1894. *Pterygia cerviceps* Fowler, B. C. A., p. 24; Tab. 2, figs. 12, 12a.  
1928. *Notocera cerviceps* Goding, Jour. N. Y. Ent. Soc., 36: 233.

Teleman, Panima, Panzos, Vera Paz (Champion, 1894).

***Notocera hispida* Fairmaire**

1846. *Pterygia hispida* Fairmaire, Rev. Memb., p. 265.  
1928. *Notocera hispida* Goding, Jour. N. Y. Ent. Soc., 36: 233.

Guatemala (Fowler, 1924).

***Scalmorphus reticulatus* Fowler**

1894. *Scalmorphus reticulatus* Fowler, B. C. A., p. 23; Tab. 2, figs. 11, 11a, 11b.  
San Geronimo, Cerro Zunil (Champion, 1894).

***Spongophorus affinis* Fowler**

1894. *Spongophorus affinis* Fowler, B. C. A., p. 29; Tab. 3, figs. 2, 2a.  
Quiche Mts., Totonicapan (Champion, 1894).

**Spongophorus ballista** Germar

1835. *Hypsauchenia ballista* Germar, Revue Silberman, 3: 231.  
 1846. *Spongophorus ballista* Fairmaire, Rev. Memb., p. 261.  
 1864. *Spongophorus claviger* Stål, Hemiptera Mexicana, p. 268.  
 1869. *Spongophorus apicalis* Stål, Bid. Memb. Kan., p. 273.  
 1891. *Spongophorus brunneus* Fallou, Rev. Ent., 9: 254.

San Juan, El Tumbador, Cerro Zunil, San Isidro (Champion, 1894).

**Spongophorus championi** Fowler

1894. *Spongophorus championi* Fowler, B. C. A., p. 28; Tab. 3, figs. 1, 1a.  
 El Reposo, San Isidro (Champion, 1894).

**Spongophorus inflatus** Fowler

1894. *Spongophorus inflatus* Fowler, B. C. A., p. 30; Tab. 3, figs. 5, 5a-c.  
 San Geronimo (Champion, 1894).

**Spongophorus robustulus** Fowler

1894. *Spongophorus robustulus* Fowler, B. C. A., p. 29; Tab. 3, figs. 3, 3a.  
 Guatemala (Fowler, 1894); Duenas (Champion, 1894); Aceituno (Salvin).

**Tylopelta gibbera** Stål

1869. *Tropidoscyta gibbera* Stål, Hemiptera Fabriciana, 2: 46.  
 1894. *Tylopelta gibbera* Fowler, B. C. A., p. 15; Tab. 2, figs. 1, 1a.  
 1894. *Tropidoscyta americana* Goding, Catalogue of Membracidae, p. 469.

Chicam, San Geronimo, Vera Paz (Champion, 1894).

Subfamily **Hoplophorinae****Alchisme grossa** Fairmaire

1846. *Triquetra grossa* Fairmaire, Rev. Memb., p. 280.  
 1851. *Triquetra virgata* Walker, List of Hom. Brit. Mus., p. 522.  
 1851. *Triquetra virescens* Walker, List Hom. B. M., p. 522.  
 1858. *Umbonia terribilis* Walker, Ins. Saund., p. 66.  
 1894. *Triquetra obtusa* Fowler, Trans. Ent. Soc. Lond., p. 417.  
 1929. *Alchisme grossa* Goding, South American Membracidae, p. 208.

Cubilguitz, Vera Paz, El Tumbador, Cerro Zunil, Panajachel, Pampojilaj (Champion, 1894).

**Metcalfiella cinerea** Fairmaire

1846. *Hoplophora cinerea* Fairmaire, Rev. Memb., p. 272.  
 1927. *Hoplophorion cinerea* Funkhouser, Catalogue Membracidae, p. 82.  
 1929. *Metcalfiella cinerea* Goding, So. Amer. Memb., p. 201.

Teleman, Panzos, Vera Paz, Capetillo (Champion, 1894); Chichicastenango, Lake Atitlan, Antigua (W. D. F., 1942).

**Metcalfiella disparipes** Fowler

1894. *Hoplophora disparipes* Fowler, B. C. A., p. 40; Tab. 3, figs. 25, 25a.  
 1903. *Ochropepla disparipes* Buckton, Mon. Memb., p. 104.  
 1927. *Hoplophorion disparipes* Funkhouser, Cat. Memb., p. 83.  
 1929. *Metcalfiella disparipes* Goding, So. Amer. Memb., p. 201.

San Geronimo (Champion, 1894).



***Metcalfiella monogramma* Germar**

1835. *Hoplophora monogramma* Germar, Rev. Silb., 3: 242.  
 1846. *Hoplophora sanguinosa* Fairmaire, Rev. Silb., p. 270.  
 1903. *Hoplophora apriformis* Buckton, Mon. Memb., p. 95.  
 1927. *Hoplophorion monogramma* Funkhouser, Cat. Memb., p. 84.  
 1929. *Metcalfiella monogramma* Goding, So. Amer. Memb., p. 210.

Cerro Zunil, (Champion, 1894); Chichicastenango, Lake Atitlan, Quetzaltenango (W. D. F., 1942).

***Platycotis discreta* Fowler**

1894. *Platycotis discreta* Fowler, B. C. A., p. 42; Tab. 4, figs. 4, 4a, 4b.

San Joaquin, Cubalco, Vera Paz (Champion, 1894); Guatemala (Funkhouser collection, collector unknown).

***Platycotis histrionica* Stål**

1864. *Hoplophora histrionica* Stål, Hem. Mex., p. 69.  
 1869. *Lophopelta histrionica* Stål, Hem. Fabr., 2: 37.  
 1894. *Platycotis histrionica* Fowler, B. C. A., p. 43; Tab. 4, figs. 5, 5a.

Cerro Zunil, San Geronimo (Champion, 1894).

***Platycotis nigrorufa* Walker**

1858. *Hemiptycha nigrorufa* Walker, List. Hom. B. M. Suppl., p. 143.  
 1894. *Platycotis nigrorufa* Fowler, B. C. A., p. 43.

Quetzaltenango (Champion, 1894; W. D. F., 1942).

***Umbonia crassicornis* Amyot and Serville**

1843. *Physoplia crassicornis* Amyot and Serville, Hemiptera, p. 453.  
 1846. *Umbonia orizimbo* Fairmaire, Rev. Memb., p. 277.  
 1846. *Umbonia crassicornis* Fairmaire, Rev. Memb., p. 275.  
 1851. *Physoplia media* Walker, List Hom. B. M., p. 516.  
 1858. *Umbonia decorata* Walker, List. Hom. B. M. Suppl., p. 3.  
 1858. *Umbonia picta* Walker, List. Hom. B. M. Suppl., p. 130.  
 1869. *Umbonia rectispina* Stål, Bid. Memb. Kan., p. 265.  
 1895. *Physoplia peracea* Griffini, Stud. Memb. Umbonia, p. 3.  
 1895. *Physoplia camerani* Griffini, Stud. Memb. Umbonia, p. 3.

Lanquin, Cahabon, San Geronimo, Vera Paz, El Tumbador, Las Mercedes, Coatepeque, El Reposo, Paraiso, Cerro Zunil, San Isidro, Volcan de Atitlan (Champion, 1894); Lake Atitlan (W. D. F., 1942).

***Umbonia reclinata* Germar**

1835. *Hoplophora reclinata* Germar, Rev. Silb., 3: 243.  
 1846. *Umbonia reclinata* Fairmaire, Rev. Memb., p. 276.  
 1854. *Umbonia funesta* Stål, Nya. Hem., p. 249.  
 1858. *Umbonia multiformis* Walker, List Hom. B. M. Suppl., p. 129.  
 1903. *Umbonia subclivata* Buckton, Mon. Memb., p. 88.

Guatemala (Salle); Lanquin, San Geronimo, Vera Paz (Champion, 1894); Chichicastenango (W. D. F., 1942).

***Umbonia ermanni* Griffini**

1895. *Umbonia ermanni* Griffini, Stud. Memb., 10: 6.  
 1903. *Enchotype* (sic) *ermannii* Buckton, Mon. Memb., p. 106.

Chichicastenango (W. D. F., 1942).

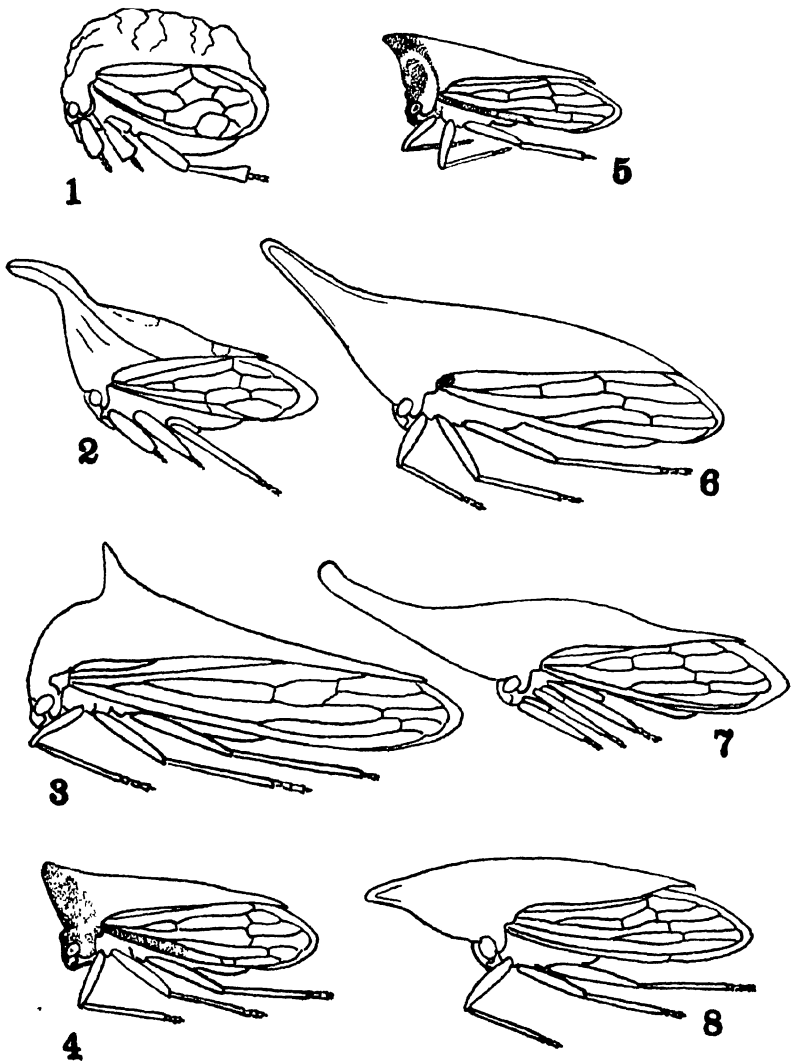


FIG. 1. *Bolbonota atilla* sp. nov. 2. *Enchenopa ansera* sp. nov. 3. *Umbonia antiqua* sp. nov. 4. *Potnia maculata* sp. nov. 5. *Potnia brunneifrons* sp. nov. 6. *Aconophora lutea* sp. nov. 7. *Aconophora coffea* sp. nov. 8. *Aconophora brevicornis* sp. nov.

**Umbonia spinosa** Fabricius

1766. *Cicada spinosa* Houttuyn, Nat. Hist., 1: 257.  
 1775. *Membracis spinosa* Fabricius, Syst. Ent., p. 675.  
 1792. *Membracis armata* Olivier, Enc. Meth., 7: 668.  
 1803. *Centrotus spinosis* Fabricius, Syst. Rhyng., p. 17.  
 1835. *Hoplophora spinosa* Germar, Rev. Silb., 3: 243.  
 1840. *Hemiptycha spinosa* Blanchard, Hem., 3: 183.  
 1835. *Umbonia spinosa* Burmeister, Handb. Ent., 2: 138.  
 1869. *Umbonia curvispina* Stål, Bid. Memb. Kan., p. 265.  
 1903. *Enchenotype* (sic) *curvispina* Buckton, Mon. Memb., p. 106.

Teleman, Vera Paz, San Isidro (Champion, 1894).

**Umbonia nigrata** Amyot and Serville

1843. *Physoplia nigrata* Amyot and Serville, Hem., p. 543.  
 1864. *Umbonia nigrata* Stål, Hem. Mex., p. 69.

Guatemala (Van Patton, date unknown; Funkhouser collection).

**Umbonia antiqua** sp. nov.

(Figure 3)

Uniformly dark reddish-brown, very coarsely punctate, irregularly ridged, sparingly pubescent; dorsal horn short, sharp, erect, rising from behind the humeral angles; posterior process slender, sharp, not reaching the tips of tegmina; tegmina entirely exposed, brown, semiopaque; under surface and legs uniformly brown; hind tarsi much shorter than first two pairs.

Head subtriangular, roughly sculptured, finely punctate, densely pubescent; base weakly arcuate; eyes dark brown; ocelli large, amber-colored, equidistant from each other and from the eyes and situated about on a line drawn through centers of eyes; inferior margins of genae sinuate; clypeus swollen, extending for half its length below inferior margins of genae, tip suddenly acuminate, densely pilose.

Pronotum reddish-brown, coarsely punctate, sparsely pubescent, irregularly longitudinally ridged; dorsal horn extending upward and very slightly forward, about twice as long as its width at base, very sharp, arising from behind the humeral angles; metopidium low, sloping, twice as wide as high; median carina strongly percurrent; humeral angles strong, robust, triquerate, extending outward and slightly forward, as long as one-fourth of the distance between their bases; posterior process slender, acuminate, extending beyond the abdomen but not reaching tips of tegmina.

Tegmina entirely exposed; brown, translucent; veins very wide and heavy; base broadly opaque, coriaceous and punctate; five apical and four discoidal cells; third apical cell truncate at base, not petiolate; apical limbus broad.

Under surface of body uniformly brown; legs brown; femora cylindrical; tibiae triquerate and expanded at the distal ends; hind tarsi much shorter than other two pairs.

Length from front of head to tips of tegmina 8.5 mm.; width between tips of humeral angles 4.8 mm.

Described from a pair taken at Antigua, Guatemala, on February 26, 1942. The male is somewhat smaller and considerably darker than the female. Holotype female and allotype male in author's collection.

***Umbonia immaculata* sp. nov.**

Large, uniformly dark green, without ridges, fossae, stripes or markings of any kind, coarsely punctate, not pubescent; dorsal horn heavy, erect, straight, sharp, arising from behind humeral angles; posterior process slender, reaching almost to tips of tegmina; tegmina entirely hyaline; under surface and legs entirely green, hind tarsi very short.

Head subquadrate, twice as wide as long, dark green, finely punctate; base arcuate and weakly sinuate; eyes green; ocelli prominent, brown, twice as far from the eyes as from each other and situated about on a line drawn through centers of eyes; inferior margins of genae rounded and flanged outward; clypeus extending for half its length below inferior margins of genae, tip pointed and pilose.

Pronotum dark green, coarsely punctate, not pubescent, without ridges, stripes or maculations; dorsal horn stout, erect, sharp, arising from behind humeral angles and extending directly upward; metopidium sloping above the head, as wide as high, smooth above base of head; humeral angles large, heavy, triangular blunt; median carina obsolete; posterior process long, slender, sharp, extending almost to tips of tegmina.

Tegmina hyaline; veins heavy; five apical and three discoidal cells; base narrowly opaque and punctate; apical limbus narrow.

Under surface dark green; legs fuscous; hind tarsi much shorter than other two pairs.

Length from front of head to tips of tegmina 13 mm.; width between tips of humeral angles 7.5 mm.

Described from a single female taken at San Jose, Guatemala, on March 2, 1942. Type in author's collection.

***Potnia maculata* sp. nov.**

(Figure 4)

Yellow with prominent brown markings on metopidium, head and tegmina, coarsely punctate, not pubescent; pronotal horn porrect, short and rounded; posterior process tectiform, sharp, not reaching apices of tegmina; tegmina entirely exposed, hyaline mottled with brown; under surface of body brown; legs yellow.

Head subquadrate, wider than long, yellow with brown markings, finely punctate, sparingly pubescent; base weakly arcuate; eyes yellow-brown; ocelli inconspicuous, yellow, equidistant from each other and from the eyes and situated about on a line drawn through centers of eyes; inferior margins of genae sloping; clypeus extending for half its length below inferior margins of genae, tip pointed and pilose.

Pronotum yellow with the metopidium brown, coarsely punctate, not pubescent; pronotal horn very short and angulate, extending upward and forward, about as long as its width at base; dorsum nearly straight from top of horn to posterior extremity; metopidium wider than high, indented above the head, then sloping forward to tip of pronotal horn, brown, finely punctate; humeral angles large, swollen, conical, blunt; median carina percurrent; posterior process

tectiform, slender, sharp, extending to a point about half way between internal angles and tips of tegmina.

Tegmina hyaline, base and basal half of costal cell coriaceous, opaque, punctate and yellow; veins heavy; five apical and three discoidal cells; terminal cell truncate, not petiolate; apical limbus narrow.

Under surface of body fuscous; femora and tibiae yellow; tarsi yellow-brown; hind tarsi very short.

Length from front of head to tips of tegmina 5.2 mm.; width between humeral angles 2.6 mm.

Described from a single male taken in sweeping roadside vegetation near the shore of Lake Atitlan, Guatemala. Type in author's collection.

***Potnia brunneifrons* sp. nov.**

(Figure 5)

Small, green with brown markings on metopidium and head, finely punctate, not pubescent; pronotal horn short, porrect, pointed; posterior process slender, acuminate, not reaching tips of tegmina; tegmina wrinkled hyaline with strong brown veins; legs and under surface of body green.

Head subquadrate, very roughly sculptured, dark brown, finely punctate, sparingly pubescent; base arcuate; eyes dark brown; ocelli amber-colored, twice as far from each other as from the eyes and situated somewhat above a line drawn through centers of eyes; inferior margins of genae sinuate; clypeus extending for half its length below inferior margins of genae, tip densely pilose.

Pronotum low, tectiform, green with dark brown markings in front, finely punctate, not pubescent; pronotal horn short, extending forward and upward above the head, about as long as its lateral width at base; dorsal margin sloping in nearly a straight line from pronotal horn to posterior process; metopidium broader than high, green with brown markings; humeral angles heavy, triangular, blunt; median carina percurrent; posterior process slender, tip sharp and extending to a point about half way from internal angles to tips of tegmina.

Tegmina entirely exposed; wrinkled hyaline; base narrowly opaque and punctate; five apical and three discoidal cells; terminal apical cell truncate, not petiolate; apical limbus narrow.

Under surface of body green marked with brown; femora and tibiae green; tarsi ferruginous; hind tarsi much shorter than other two pairs.

Length from front of head to tips of tegmina 4.3 mm.; width between humeral angles 2 mm.

Described from a single male taken at Chichicastenango, Guatemala, on February 13, 1942.

Subfamily **Darninae****Aconophora caliginosa** Walker

1858. *Aconophora caliginosa* Walker, List Hom. B. M. Suppl., p. 135.

Guatemala (Deby, 1858); Chacoj, Lanquin, Vera Paz, Coatepec (Champion, 1894); Quetzaltenango (W. D. F., 1942).

**Aconophora disparicornis** Fowler

1895. *Aconophora disparicornis* Fowler, B. C. A., p. 69; Tab. 5, figs. 17, 17a.

Chichicastenango (W. D. F., 1942); Guatemala (Funkhouser collection, collector and date unknown).

**Aconophora ensata** Fowler

1895. *Aconophora ensata* Fowler, B. C. A., p. 68; Tab. 5, figs. 14, 14a.

Guatemala (Salle).

**Aconophora ferruginea** Fowler

1895. *Aconophora ferruginea* Fowler, B. C. A., p. 69; Tab. 5, figs. 16, 16a.

Los Amates (Kellerman).

**Aconophora laminata** Fairmaire

1846. *Aconophora laminata* Fairmaire, Rev. Memb., p. 294.

Chichicastenango (W. D. F., 1942).

**Aconophora laticornis** Walker

1858. *Aconophora laticornis* Walker, List Hom. B. M. Suppl., p. 134.

Guatemala (Salle) (Van Patten); San Geronimo, Cerro Zunil, Totonicapan (Champion, 1894); Quetzaltenango (W. D. F., 1942).

**Aconophora marginata** Walker

1851. *Aconophora marginata* Walker, List Hom. B. M., p. 540.

1858. *Aconophora stabilis* Walker, List Hom. B. M. Suppl., p. 135.

1859. *Aconophora concolor* Dohrn, Cat. Hem., p. 79.

1869. *Aconophora nigra* Stål, Hem. Fabr., 2: 35.

1929. *Aconophora gracilicornis* Goding, So. Amer. Memb., p. 231.

Purula, San Geronimo, Vera Paz, Guatemala City (Champion, 1894); Guatemala City (W. D. F., 1942).

**Aconophora mexicana** Stål

1864. *Aconophora mexicana* Stål, Hem. Mex., p. 70.

Guatemala (Fowler, 1895).

**Aconophora nigricornis** Fowler

1895. *Aconophora nigricornis* Fowler, B. C. A., p. 64; Tab. 5, figs. 10, 10a.

Chicam, San Geronimo, Vera Paz (Champion, 1894).

**Aconophora pallescens** Stål

1869. *Aconophora pallescens* Stål, Hem. Fabr., 2: 35.

San Geronimo, Coban, Vera Paz (Champion, 1894).

***Aconophora pubescens* Walker**

1858. *Aconophora pubescens* Walker, Ins. Saund., p. 70.  
 1878. *Aconophora spathata* Butler, Cist. Ent., 2: 347.  
 1928. *Guayquila pubescens* Goding, Jour. N. Y. Ent. Soc., 36: 225.

Rio Maria, Linda, San Geronimo (Champion, 1894); Guatemala (Funkhouser collection, collector and date unknown).

***Aconophora sinanjensis* Fowler**

1895. *Aconophora sinanjensis* Fowler, B. C. A., p. 70; Tab. 3, figs. 20, 20a, 21.  
 Sinanja (Champion, 1894); Lake Atitla (W. D. F., 1942).

***Aconophora temaxia* Fowler**

1895. *Aconophora temaxia* Fowler, B. C. A., p. 70.  
 Guatemala (Osborn, 1909).

***Aconophora lutea* sp. nov.**

(Figure 6)

Entirely bright shining yellow without markings, finely punctate, not pubescent; pronotal horn porrect, flattened laterally, half as long as the body; posterior process heavy, reaching just to tip of abdomen but not reaching tips of tegmina; tegmina hyaline with black spot at base; under surface and legs yellow.

Head subquadrate, wider than long, yellow, finely punctate; base weakly arcuate; eyes yellow; ocelli yellow, equidistant from each other and from the eyes; inferior margins of genae sinuate; clypeus extending for half its length below inferior margins of genae, tip pilose.

Pronotum bright yellow, finely punctate, not pubescent; pronotal horn heavy, flattened laterally, margins foliaceous, extending upward and forward; dorsum rounded; metopidium sloping forward in front of head to base of pronotal horn; lateral angles small, triangular, blunt; median carina obsolete except on the horn where it is sharp and extended; posterior process tectiform, heavy, tip sharp and extending just to end of abdomen but not reaching tips of tegmina.

Tegmina hyaline; base broadly yellow, coriaceous and punctate, with a black spot just behind humeral angles; five apical and four discoidal cells; base of third apical cell truncate, not petiolate; apical limbus broad.

Under surface of body yellow; femora yellow marked with black; tibiae and tarsi yellow.

Length from front of head to tips of tegmina 6.5 mm.; length from eye to tip of horn 4 mm.; width between humeral angles 3 mm.

Described from a single male taken at San Jose, Guatemala, on March 2, 1942. Type in author's collection.

***Aconophora coffea* sp. nov.**

(Figure 7)

Rich coffee-brown, finely punctate, sparingly pubescent; pronotal horn porrect, laterally compressed, slightly upturned at tip, half as long as body; posterior process slender, reaching well beyond tip of

abdomen but not to tips of tegmina; tegmina entirely brown; under surface and legs brown.

Head subquadrate, wider than long, finely punctate, sparsely pubescent; base arcuate; eyes brown; ocelli glassy, equidistant from each other and from the eyes; inferior margins of genae sloping; clypeus extending for half its length below inferior margins of genae, tip pilose.

Pronotum brown, finely punctate, sparsely pubescent; pronotal horn heavy, blunt, extending forward and upward, tip slightly upturned, margins flattened; dorsum convex; metopidium sloping forward from head to base of horn; median carina percurrent; posterior process slender, sharp, extending beyond end of abdomen but not reaching tips of tegmina.

Tegmina brown, translucent; base narrowly opaque and punctate; veins strong; five apical and four discoidal cells; terminal cell truncate, not petiolate; apical limbus broad.

Under surface brown; femora brown; tibiae and tarsi ferruginous.

Length from front of head to tips of tegmina 6 mm.; length from eye to tip of horn 4 mm.; width between humeral angles 2.8 mm.

Described from a single male taken on a small coffee tree in the patio of the Palace Hotel, Guatemala City, Guatemala, on March 7, 1942. Type in author's collection.

***Aconophora brevicornis* sp. nov.**

(Figure 8)

Uniformly bright yellow, finely punctate, sparingly pubescent; pronotal horn very short, stout, laterally compressed, extending directly forward; dorsum regularly arcuate; posterior process suddenly acute, not reaching apex of tegmen; under surface and legs entirely pale yellow.

Head subquadrate, twice as wide as long, pale yellow, smooth, densely pubescent with short yellow hairs; base nearly straight; eyes yellow; ocelli small, yellow, opaque, nearer to each other than to the eyes and situated about on a line drawn through centers of eyes; inferior margins of genae strongly sinuate; clypeus extending for half its length below inferior margins of genae, tip rounded and densely pilose.

Pronotum entirely pale yellow, finely punctate, sparsely pubescent; pronotal horn short, heavy, blunt, anterior half compressed laterally, extending straight forward over the head; dorsum regularly but feebly arcuate from tip of horn to apex of posterior process; metopidium sloping in front of head to base of horn, wider than high; humeral angles short and rounded; median carina faintly percurrent; posterior process suddenly acute, tip reaching just beyond internal angles of tegmina.

Tegmina entirely free; yellowish hyaline with yellow veins; base broadly coriaceous, opaque and punctate; five apical and four discoidal cells; terminal apical cell truncate, not petiolate; apical limbus broad.

Under surface of body yellow; legs entirely yellow; femora cylindrical; tibiae triquerate.



Length from front of head to tips of tegmina 5.5 mm.; length from top of head to tip of horn 2.6 mm.; width between humeral angles 3 mm.

Described from a single female taken at Antigua, Guatemala. Type in author's collection.

***Aspona cuneata* Fowler**

1894. *Aspona cuneata* Fowler, B. C. A., p. 51; Tab. 4, figs. 14, 14a, 14b.  
Chichicastenango (W. D. F., 1942).

***Aspona turgescens* Fowler**

1894. *Aspona turgescens* Fowler, B. C. A., p. 50; Tab. 4, figs. 12, 12a-c.  
Cubilguitz, Vera Paz (Champion, 1894).

***Cymbomorpha prasina* Germar**

1835. *Smilia prasina* Germar, Rev. Silb., 3: 234.  
1846. *Smilia nigrofasciata* Fairmaire, Rev. Memb., p. 292.  
1858. *Smilia lepida* Walker, List. Hom. B. M. Suppl., p. 133.  
1869. *Aulacotropis prasina* Stål, Hem., 2: 34.  
1869. *Cymbomorpha prasina* Stål, Bid. Memb. Kan., p. 260.

Cubilguitz, Vera Paz (Champion, 1894).

***Darnis lateralis* Fabricius**

1801. *Membracis lateralis* Coquebert, Ill. Ins., 2: 78 (nom. nud.).  
1803. *Darnis lateralis* Fabricius, Syst. Rhyng., 2: 27.

Guatemala (Funkhouser collection, collector and date unknown).

***Darnoides affinis* Fowler**

1894. *Darnoides affinis* Fowler, B. C. A., p. 82; Tab. 6, figs. 14, 14a, 14b.  
El Reposo (Champion, 1894).

***Entaphius funebris* Buckton**

1903. *Entaphius funebris* Buckton, Mon. Memb., p. 134; Pl. 28, figs. 6, 6a.  
San Geronimo (Buckton, 1903).

***Hebeticoides acutus* Fowler**

1894. *Hebeticoides acutus* Fowler, B. C. A., p. 53; Tab. 4, figs. 17, 17a-d.  
Panima, Vera Paz (Champion, 1894).

***Heteronotus trinodosus* Butler**

1878. *Heteronotus trinodosus* Butler, Cist. Ent., 2: 357; Pl. 7, fig. 8.  
Panzos, Vera Paz (Champion, 1894).

***Hyphinoe asphaltina* Fairmaire**

1846. *Hemiptycha asphaltina* Fairmaire, Rev. Memb., p. 319; Pl. 6, fig. 20.  
1858. *Hemiptycha apriformis* Walker, List Hom. B. M. Suppl., p. 144.  
1858. *Hemiptycha pubescens* Walker, List Hom. B. M. Suppl., p. 144.  
1869. *Hyphinoe asphaltina* Stål, Bid. Hem. Syst., p. 558.  
1869. *Hyphinoe morio* Stål, Bid. Memb. Kan., p. 257.  
1869. *Hyphinoe* (sic) *asphaltina* Osborn, Ohio Nat., 9: 458.

Perula, Senahu, El Tumbador, Volcan de Atitla, Capetillo (Champion, 1895); Guatemala (Osborn, 1909).

**Hyphinoe bigutta** Walker

1858. *Hemiptycha bigutta* Walker, List Hom. B. M. Suppl., p. 142.  
1878. *Hyphinoe bigutta* Butler, Cist. Ent., 2: 245.

El Reposo, Pantaleon, Volcan de Atitlan (Champion, 1895).

**Hyphinoe cuneata** Germar

1835. *Hemiptycha cuneata* Germar, Rev. Silb., 3: 246.  
1846. *Hemiptycha globiceps* Fairmaire, Rev. Memb., p. 319.  
1867. *Hyphinoe cuneata* Stål, Bid. Hem. Syst., p. 558.

Guatemala (Van Patton).

**Hyphinoe marginalis** Fallou

1890. *Hyphinoe marginalis* Fallou, Rev. Ent., 9: 353.

Guatemala (Salle, 1890).

**Hyphinoe tau** Fowler

1895. *Hyphinoe tau* Fowler, B. C. A., p. 76; Tab. 6, figs. 1, 1a, 1b.  
1903. *Hyphinoe subfusca* Buckton, Mon. Memb., p. 122.  
1903. *Hyphinoe atitlana* Buckton, Mon. Memb., p. 122.  
1930. *Ceresa subfusca* Goding, Amer. Mus. Novit., p. 18.

El Reposo, Volcan de Atitlan (Champion, 1895); Lake Atitlan (W. D. F., 1942; Costepeque (Funkhouser collection, collector unknown).

**Hyphinoe ochracea** Fowler

1895. *Hyphinoe ochracea* Fowler, B. C. A., p. 78; Tab. 6, figs. 8, 8a.

Guatemala (Mus. Roy. Belg.; Mus. Holm.).

**Hyphinoe purulensis** Fowler

1895. *Hyphinoe purulensis* Fowler, B. C. A., p. 77; Tab. 6, figs. 4, 4a, 4b, 5, 5a, 5b.

Purula, Sabo (Champion, 1895).

**Procyrtia intectus** Fowler

1895. *Dysyncritus intectus* Fowler, B. C. A., p. 81; Tab. 6, figs. 13, 13a, 13b.  
1927. *Procyrtia intectus* Funkhouser, Cat. Memb., p. 153.

San Juan, Pantaleon (Champion, 1925).

**Stictopelta acutula** Fairmaire

1846. *Darnis acutula* Fairmaire, Rev. Memb., p. 481.  
1846. *Darnis brevis* Fairmaire, Rev. Memb., p. 483.  
1878. *Cryptoptera acutula* Butler, Cist. Ent., 2: 342.  
1895. *Stictopelta acutula* Fowler, B. C. A., p. 60; Tab. 5, figs. 6, 6a, 6b.

Chicam, Cerro Zunil, Zapote (Champion, 1895).

**Stictopelta assimilis** Fowler

1895. *Stictopelta assimilis* Fowler, B. C. A., p. 57.

Duenas (Champion, 1895).

**Stictopelta indeterminata** Walker

1858. *Darnis indeterminata* Walker, List Hom. B. M. Suppl., p. 148.  
1883. *Stictopelta wisae* Berg, Ann. Soc. Cien. Arg., 16: 289.  
1895. *Stictopelta indeterminata* Fowler, B. C. A., p. 59; Tab. 5, figs. 5, 5a, 5b.

Teleman, Vera Paz (Champion, 1895).

**Tomogonia vittatipennis** Fairmaire1846. *Smilia vittatipennis* Fairmaire, Rev. Memb., p. 293; Pl. 5, fig. 3.1869. *Tomogonia vittatipennis* Stål, Bid. Memb. Kan., p. 258.

Guatemala (Signoret, 1895).

Subfamily **Tragopinae****Tragopa testudina** sp. nov.

(Figure 9)

Large, finely punctate, not pubescent; flavous with small irregular brown markings and with three large black spots on dorsum, one in front and one on each side; pronotum testudinate, arcuate, longer than broad; humeral angles auriculate; subhumeral projections flat and rounded; tegmina almost entirely hidden under pronotum; under surface flat and flavous.

Head subquadrate, twice as broad as long, tinged with red, roughly sculptured, not punctate, not pubescent; base weakly arcuate; eyes black; ocelli large, glassy, twice as far from each other as from the eyes and situated about on a line drawn through centers of eyes; inferior margins of genae very short and rounded; clypeus twice as broad as long, truncate, extending only slightly below inferior margins of genae.

Pronotum yellowish with irregular brown markings and with three large black spots, one on the anterior margin covering most of the metopidium and one on each side extending from the lateral margin almost to the median dorsal line; pronotum arcuate and covering the entire body and tegmina like the carapace of a turtle; longer than broad; finely punctate; not pubescent; metopidium twice as broad as high, black; median carina obsolete; humeral angles extended outward into triangular auriculate processes; subhumeral plates broad and flat, extending downward and outward almost as far as the humeral angles; no distinct posterior process.

Tegmina almost entirely concealed by the pronotum; exposed basal portion black; corium with two discoidal cells; apical limbus very broad and wrinkled.

Under surface yellowish marked with black; legs flavous.

Maximum length 5 mm.; width between humeral angles 4.8 mm.

Described from three specimens, one male and two females, all collected at Guatemala City, Guatemala, on March 7, 1942. Holotype female, allotype male, and paratype female, in author's collection.

Subfamily **Smiliinae**Tribe **Ceresini****Acutalis fusconervosa** Fairmaire1846. *Acutalis fusconervosa* Fairmaire, Rev. Memb., p. 498.

San Juan, Senahu, Las Mercedes, Panajachel (Champion, 1895); Guatemala (Osborn, 1909).

***Ceresa nigrovittata* Fowler**

1895. *Ceresa nigrovittata* Fowler, B. C. A., p. 104; Tab. 7, figs. 12, 12a.  
Sabo, Vera Paz (Champion, 1894).

***Ceresa testacea* Fairmaire**

1846. *Ceresa testacea* Fairmaire, Rev. Memb., p. 284.  
1851. *Ceresa alia* Walker, List Hom. B. M., p. 529.  
1859. *Ceresa cavicornis* Stål, Freg. Eus. Rega Ins., p. 284.  
1878. *Ceresa stalii* Butler, Cist. Ent., 2: 217.

La Tinta, Chicam, San Geronimo (Champion, 1895); Chichicastenango (W. D. F., 1942).

***Ceresa vitulus* Fabricius**

1775. *Membracis vitulus* Fabricius, Syst. Ent., p. 677.  
1803. *Centrotus vitulus* Fabricius, Syst. Rhyng., 4: 20.  
1820. *Centrotus pallens* Germar, Mag. Ent., 3: 25.  
1835. *Smilia vitulus* Burmeister, Handb. Ent., 2: 137.  
1846. *Ceresa spinifera* Fairmaire, Rev. Memb., p. 284.  
1858. *Ceresa curvilinea* Walker, List Hom. B. M. Suppl., p. 132.  
1878. *Ceresa rufescens* Butler, Cist. Ent., 2: 218.  
1878. *Ceresa distans* Butler, Cist. Ent., 2: 218.  
1929. *Ceresa excisa* Goding, So. Amer. Memb., p. 261.

El Reposo (Champion, 1895).

***Ceresa rubra* sp. nov.**

(Figure 10)

Large, bright red, coarsely punctate, not pubescent; suprahumerals short and blunt; posterior process sharp, reaching just beyond the base of the terminal cell of the tegmen; tegmina hyaline; under surface and legs reddish-yellow.

Head subtriangular, roughly sculptured, finely punctate; base feebly arcuate; eyes dark brown; ocelli large, amber-colored, equidistant from each other and from the eyes and situated well below a line drawn through centers of eyes; inferior margins of genae rounded and weakly sinuate; clypeus extending for half its length below inferior margins of genae, tip rounded and pilose.

Pronotum blood-red, brighter on the angles; strongly arcuate above, a deep semicircular depression on each side, coarsely punctate, not pubescent; metopidium broader than high, straight above the head and then rounded to top of dorsum; suprahumeral horns short, blunt, triangular, bright red; median carina strong and percurrent; posterior process suddenly acuminate, red, extending to a point just beyond the base of the third apical cell of the tegmen.

Tegmina hyaline; base narrowly opaque and punctate; four discoidal and five apical cells; terminal cell petiolate; apical margin very broad.

Legs and under surface of body light reddish-yellow; femora cylindrical; tibiae triquerate and spined; tarsi pilose; claws red.

Length from front of head to tips of tegmina 8 mm.; width between tips of suprahumerals 4.2 mm.

Described from four males, all collected at Chichicastenango, Guatemala, on February 20, 1942. Holotype and three paratypes in author's collection.

***Ceresa viridilineata* sp. nov.**

(Figure 11)

Narrow-bodied, slender, coarsely punctate, sparingly pubescent; distinguished by two apple-green stripes on each side of pronotum; suprahumeral long, recurved, very sharp; posterior process very slender, reaching to base of terminal cell of tegmen; tegmina hyaline; legs and under surface testaceous.

Head subtriangular, smooth, not punctate, not pubescent, shining, testaceous; base arcuate in center; eyes black; ocelli large, amber-colored, somewhat nearer to each other than to the eyes and situated about on a line drawn through centers of eyes; inferior margins of genae sinuate; clypeus long and slender, extending for two-thirds its length below inferior margins of genae, tip rounded and pilose.

Pronotum testaceous with two bright green stripes on each side, one arcuate from the suprahumeral to the base of the posterior process, the other following the inferior margin of the pronotum; coarsely punctate, sparingly pubescent; metopidium broader than high, straight above the head; suprahumeral horns long, sharp and recurved, about as long as half the distance between their bases, extending outward and curving backward; median carina faintly percurrent; humeral angles triangular and blunt; posterior process very slender, sharp, extending as far as the base of the third apical cell of the tegmen.

Tegmina hyaline; base narrowly coriaceous and punctate; veins strong; five apical and four discoidal cells; apical limb broad and wrinkled.

Legs and under surface of body uniformly testaceous; femora cylindrical; tibiae triquerate with black spines; tarsi pilose.

Length from front of head to tips of tegmina 7.8 mm.; width between tips of suprahumeral horns 4.5 mm.

Described from four specimens, one male and three females, all taken at Quetzaltenango, Guatemala, on February 16, 1942. Holotype male, allotype female, and two paratype females in author's collection.

***Cyphonia clavata* Fabricius**

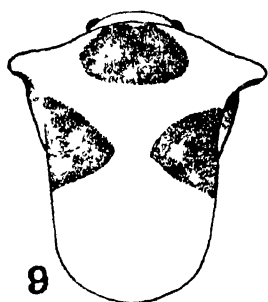
1780. Figure, Stoll, Cicag. Tab. 21, fig. 115.  
 1778. *Membracis clavata* Fabricius, Mant. Ins., 2: 264.  
 1799. *Centrotus clavatus* Coquebert, Ill. Icon., Tab. 18, fig. 5.  
 1821. *Membracis bulbifera* Germar, Mag. Ent., 4: 80.  
 1833. *Combophora clavata* Burmeister, Rev. Silb., 1: 230.  
 1843. *Cyphonia clavata* Amyot and Serville, Hem., p. 548.  
 1858. *Cyphonia hispida* Walker, List Hom. B. M. Suppl., p. 156.

Mirandilla (Champion, 1895); San Jose (W. D. F., 1942); Santa Lucia (Ohio State University collection, 1905).

***Euritea munda* Walker**

1858. *Parmula munda* Walker, List Hom. B. M. Suppl., p. 152.  
 1860. *Phacusa nigripes* Stål, Bid. Memb. Kan., p. 248.  
 1894. *Parmula nigripes* Goding, Cat. Memb., p. 411.  
 1895. *Euritea munda* Fowler, B. C. A., p. 113; Tab. 7, figs. 23, 23a.

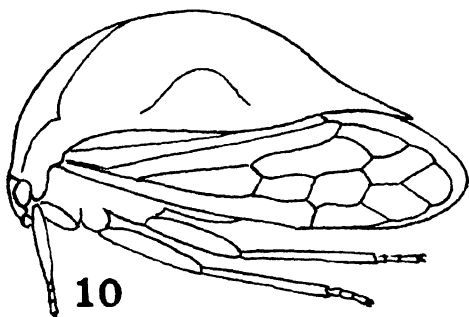
Guatemala (Deby, 1858); Cubilguitz, Vera Paz, Volcan de Atitlan (Champion, 1895).



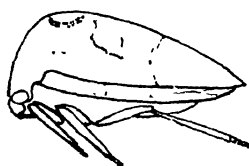
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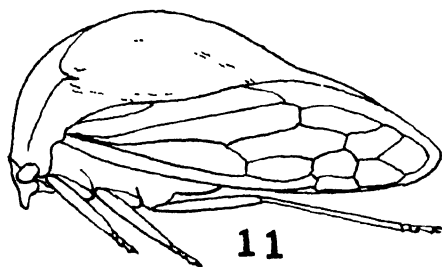
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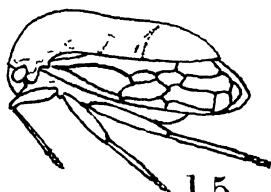
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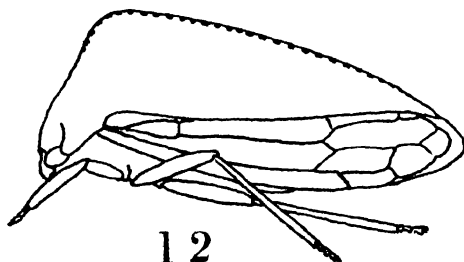
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FIG. 9. *Tragopa testudina* sp. nov. 10. *Ceresa rubra* sp. nov. 11. *Ceresa viridilineata* sp. nov. 12. *Anisianthe chichiana* sp. nov. 13. *Aphetea nigropicta* sp. nov. 14. *Amastiris pacifica* sp. nov. 15. *Vandusea mayana* sp. nov.

***Microtalis balteata* Fairmaire**

1846. *Acutalis balteata* Fairmaire, Rev. Memb., p. 496.  
 1895. *Microtalis balteata* Fowler, B. C. A., p. 116.  
 1903. *Microtalis ballista* (sic) Buckton, Mon. Memb., p. 219.

Cerro Zunil (Champion, 1895).

***Microtalis ephippium* Burmeister**

1836. *Tragopa ephippium* Burmeister, Rev. Silb., 4: 191.  
 1846. *Horiola ephippium* Fairmaire, Rev. Memb., p. 493.  
 1846. *Acutalis binaria* Fairmaire, Rev. Memb., p. 497.  
 1851. *Horiola ephippium* Walker, List Hom. B. M., p. 586.  
 1858. *Acutalis moesta* Stål, Rio Jan. Hem., 2: 33.  
 1859. *Horiola biplaga* Walker, Journ. Ent., 1: 5.  
 1883. *Acutalis variabilis* Berg, Ann. Soc. Cien. Arg., 16: 244.  
 1895. *Microtalis moesta* Fowler, B. C. A., p. 85.  
 1907. *Microtalis mutibilis* Baker, Can. Ent., 39: 116.  
 1927. *Microtalis ephippium* Funkhouser, Cat. Memb., p. 217.  
 1929. *Microtalis binaria* Goding, So. Amer. Memb., p. 293.

Guatemala City (Champion, 1895).

***Microtalis lugubrina* Stål**

1858. *Acutalis lugubrina* Stål, Rio Jan. Hem., 2: 32.  
 1895. *Microtalis lugubrina* Fowler, B. C. A., p. 120.

Quetzaltenango (Champion, 1895); Guatemala (Osborn, 1909)

***Parantonae dipteroides* Fowler**

1895. *Parantonae dipteroides* Fowler, B. C. A., p. 102; Tab. 7, figs. 10, 10a.

Aceytuno (Salvin, 1895).

***Poppea affinis* Fowler**

1895. *Poppea affinis* Fowler, B. C. A., p. 100; Tab. 7, figs. 8, 8a, 8b.

Teleman (Champion, 1895).

***Poppea reticulata* Fowler**

1895. *Poppea reticulata* Fowler, B. C. A., p. 101.

Panajachel (Champion, 1895).

***Poppea rectispina* Fairmaire**

1846. *Cyphonia rectispina* Fairmaire, Rev. Memb., p. 502.  
 1867. *Poppea rectispina* Stål, Bid. Hem. Syst., p. 551.

San Juan, Cerro Zunil (Champion, 1895); Chichicastenango (W. D. F., 1942).

***Poppea subrugosa* Fowler**

1895. *Poppea subrugosa* Fowler, B. C. A., p. 99; Tab. 7, figs. 5, 5a, 5b.

Cerro Zunil (Champion, 1895).

***Poppea torva* Fowler**

1895. *Poppea torva* Fowler, B. C. A., p. 98; Tab. 7, figs. 4, 4a, 4b.

Las Mercedes (Champion, 1895).

**Thrasymedes dubia** Fowler1895. *Phacusa dubia* Fowler, B. C. A., p. 112.1927. *Thrasymedes dubia* Funkhouser, Cat. Memb., p. 232.

Cerro Zunil (Champion, 1895).

**Thrasymedes major** Fowler1895. *Phacusa major* Fowler, B. C. A., p. 111; Tab. 7, figs. 20, 20a.1927. *Thrasymedes major* Funkhouser, Cat. Memb., p. 232.

Volcan de Agua, San Geronimo (Champion, 1895).

**Thrasymedes varieta** Fowler1895. *Phacusa varieta* Fowler, B. C. A., p. 111.1927. *Thrasymedes varieta* Funkhouser, Cat. Memb., p. 233.

Quiche Mts., Totonicapam, San Geronimo (Champion, 1895).

Tribe **Telamonini****Palonica satyrus** Fowler1896. *Telamona satyrus* Fowler, B. C. A., p. 145; Tab. 9, figs. 9, 9a.1931. *Palonica satyrus* Ball, Ent. Amer., 12: 38.

San Geronimo, Quiche Mts. (Champion, 1895).

Tribe **Smiliini****Antianthe expansa** Germar1835. *Hemiptycha expansa* Germar, Rev. Silb., 3: 245.1835. *Hemiptycha cucullata* Burmeister, Hand. Ent., 2: 140.1846. *Thelia expansa* Fairmaire, Rev. Memb., p. 309.1859. *Thelia cucullata* Dohrn, Cat. Hem., p. 79.1867. *Janthe expansa* Stål, Bid. Hem. Syst., p. 554.1895. *Antianthe expansa* Fowler, B. C. A., p. 137.

Panzos, Cubilguitz, San Geronimo, San Isidro, Cerro Zunil, Guatemala City (Champion, 1895); Chichicastenango, Atitlan, Guatemala City (W. D. F., 1942).

**Antianthe foliacea** Stål1864. *Smilia foliacea* Stål, Hem. Mex., p. 71.1867. *Janthe foliacea* Stål, Bid. Hem. Syst., p. 554.1895. *Antianthe foliacea* Fowler, B. C. A., p. 138.

San Juan, San Geronimo (Champion, 1895); Chichicastenango (W. D. F., 1942); Guatemala (Van Patton).

**Antianthe humilis** Buckton1903. *Antianthe humilis* Buckton, Mon. Memb., p. 191; Pl. 41, fig. 4.

San Geronimo (Champion, 1895); Chichicastenango (W. D. F., 1942).

**Antianthe reversa** Walker1858. *Thelia reversa* Walker, Ins. Saund., p. 72.

. Antigua (W. D. F., 1942).



***Antianthe viridissima* Walker**1858. *Thelia viridissima* Walker, List. Hom. B. M. Suppl., p. 138.1895. *Antianthe viridissima* Fowler, B. C. A., p. 138.

Chichicastenango (W. D. F., 1942); Guatemala (Van Patton).

***Antianthe chichiana* sp. nov.**

(Figure 12)

Dark green, coarsely punctate, not pubescent; edge of dorsal crest margined with black spots; humeral angles large and auriculate; dorsum highest above humeral angles, then roundly sloping to apex; posterior process heavy, blunt, reaching almost to apex of tegmen; tegmina hyaline, inner third covered by pronotum; legs and under surface uniformly green.

Head triangular, green, coarsely punctate; base strongly sinuate; eyes brown; ocelli black, equidistant from each other and from the eyes and situated about on a line drawn through centers of eyes; inferior margins of genae straight; clypeus heavy, blunt, extending for half its length below inferior margins of genae and continuing the line of the face made by these margins.

Pronotum dark green, coarsely punctate, not pubescent; dorsum tectiform, rising abruptly above the head, highest above humeral angles, then arcuate to tip of posterior process; dorsal crest margined with black spots; metopidium sloping backward above head to top of crest; median carina strongly percurrent; humeral angles extended into heavy flat auriculate processes which extend directly outward, a little longer than broad and about as long as half the distance between their bases; posterior process heavy, blunt, tectiform, extending almost to tips of tegmina.

Tegmina hyaline; veins heavy; base narrowly opaque and coriaceous; inner third of tegmina concealed under pronotum; apical limbus broad; five apical and three discoidal cells; terminal apical cell petiolate.

Under surface light green; legs testaceous-green; femora cylindrical; tibiae triquerate and feebly spined; claws black.

Length from front of head to tips of tegmina 7.8 mm.; width between tips of humeral angles 5.5 mm.

Described from eight specimens, five males and three females, all taken at Chichicastenango, Guatemala, in February 1942. Holotype female, allotype male, and six paratypes in author's collection.

***Aphetea inconspicua* Fowler**1895. *Aphetea inconspicua* Fowler, B. C. A., p. 95; Tab. 6, figs. 25, 25a, 26, 26a.

Chacoj, Cahabon, Vera Paz (Champion, 1895).

***Aphetea nigropicta* sp. nov.**

(Figure 13)

Small; light green with jet black markings, finely punctate, not pubescent; dorsum low, arcuate, three black spots on crest; sides of pronotum irregularly ridged and with a black line before the posterior

process; tegmina two-thirds concealed by pronotum, exposed part black except for a transparent spot in center; posterior process blunt and just reaching tips of tegmina; under surface green; legs green marked with black.

Head triangular, green punctate with black; roughly sculptured, not pubescent; base sinuate; eyes dark brown; ocelli large, prominent, glassy, equidistant from each other and from the eyes and situated on a line drawn through centers of eyes; inferior margins of genae rounded; clypeus extending for half its length beyond inferior margins of genae and continuing the line of the face made by these margins, tip blunt and pilose; under surface of head jet black.

Pronotum light green, finely punctate, not pubescent; dorsum low, arcuate, three black spots on margin of crest; sides of pronotum with three or four irregular carinae; a vertical black stripe at base of posterior process; posterior process short, blunt, extending just to tips of tegmina; metopidium low, broader than high; median carina sharp and strongly percurrent; humeral angles short, blunt, triangular.

Tegmina more than half concealed under the pronotum; concealed portion hyaline; exposed portion jet black except for a hyaline spot just behind center; venation almost indistinguishable because of black color; apical limbus very narrow.

Under surface green spotted with black; femora green; tibiae green with apices black; tarsi green; claws black.

Length from front of head to tips of tegmina 5 mm.; width between humeral angles 2.2 mm.

Described from three specimens, two females and one male, all taken at San Jose, Guatemala, on March 2, 1942. Holotype female, allotype male, and paratype female in author's collection.

#### ***Grandolobus vittatipennis* Fowler**

1896. *Cyrtolobus vittatipennis* Fowler, B. C. A., p. 142.

Quiche Mts. (Champion, 1895).

#### ***Ophiderma mus* Fowler**

1896. *Ophiderma mus* Fowler, B. C. A., p. 143; Tab. 9, figs. 3, 3a.

Quiche Mts. (Champion, 1895).

#### **Tribe Polyglyptini**

#### ***Adippe inaequalis* Fowler**

1896. *Adippe inaequalis* Fowler, B. C. A., p. 136; Tab. 8, figs. 20, 20a.

San Juan, Vera Paz (Champion, 1895).

#### ***Adippe zebrina* Fairmaire**

1846. *Oxygonia zebrina* Fairmaire, Rev. Memb., p. 305.

1858. *Oxygonia figurata* Walker, List Hom. B. M. Suppl., p. 137.

1867. *Adippe zebrina* Stål, Bid. Hem. Syst., p. 555.

El Tumbador, Las Mercedes, Purula (Champion, 1895).

***Amastris funkhouseri* Haviland**1925. *Amastris funkhouseri* Haviland, *Zoologica*, 6: 3; Pl. 3, fig. 9.

San Jose (W. D. F., 1942).

***Amastris pacifica* sp. nov.**

(Figure 14)

Small, fuscous, mottled with dark brown and white, roughly sculptured, finely punctate, not pubescent; a deep indentation on each side of pronotum just below dorsal margin; a white stripe before posterior process; dorsum regularly arched, highest before middle; posterior process heavy, reaching beyond tegmina; two-thirds of tegmen covered by pronotum; basal area of costal margin of tegmen coriaceous and opaque; under surface and legs fuscous.

Head subtriangular, convex, finely punctate, yellow; base sinuate; eyes translucent white; ocelli prominent, white, twice as far from each other as from the eyes and situated about on a line drawn through centers of eyes; inferior margins of genae rounded; clypeus extending for half its length below margins of genae and continuing the line of the face made by these margins, tip rounded and pilose.

Pronotum tectiform, roughly sculptured; dorsum regularly arcuate, highest before middle; finely punctate, not pubescent; a deep brown depression on each side near dorsal margin; a brown arcuate fascium before this depression; a vertical white stripe across pronotum behind middle; metopidium vertical above head, as high as broad; median carina sharply percurrent; humeral angles prominent, triangular, blunt; posterior process heavy, acute, extending just beyond apices of tegmina.

Tegmina only one-third exposed below margins of pronotum; exposed portion opaque, coriaceous and punctate on basal two-thirds, hyaline on apical third; apical limbus very narrow.

Under surface of body fuscous; legs fuscous with apices of tibiae marked with brown.

Maximum length 4.2 mm.; width between humeral angles 2 mm.

Described from ten females and nine males, all collected at San Jose, Guatemala, on March 2, 1942. Holotype female, allotype male, and seventeen paratypes in author's collection.

***Boethoos distinguenda* Fowler**1895. *Parmula distinguenda* Fowler, B. C. A., p. 91; Tab. 6, figs. 21, 21a, 21b.1925. *Boethoos distinguenda* Haviland, *Zoologica* VI: 3, p. 250.

Panima, Telemán, Cubilguitz (Champion, 1895); Guatemala (Funkhouser collection, collector unknown).

***Entylia gemmata* Germar**1818. *Membracis gemmata* Germar, *Mag. Ent.*, 4: 16.1835. *Entylia gemmata* Germar, *Rev. Silb.*, 3: 248.1846. *Entylia cornicula* Fairmaire, *Rev. Memb.*, p. 300.1851. *Entylia incisa* Walker, *List Hom. B. M.*, p. 548.

San Joaquin, Vera Paz (Champion, 1895).

**Entylia sinuata** Fabricius

1798. *Membracis sinuata* Fabricius, Ent. Syst. Suppl., p. 513.  
 1798. *Membracis emarginata* Fabricius, Ent. Syst. Suppl., p. 513.  
 1833. *Darnis sinuata* Germar, Rev. Silb., 1: 78.  
 1835. *Hemiptycha sinuata* Burmeister, Handb. Ent., 2: 140.  
 1846. *Entylia sinuata* Fairmaire, Rev. Memb., p. 300.  
 1851. *Thelia sinuata* Walker, List Hom. B. M., p. 1144.  
 1877. *Entylia mira* Butler, Cist. Ent., 2: 212.  
 1896. *Entylia inaequalis* Fowler, B. C. A., p. 130.  
 1903. *Entylia oedipus* Buckton, Mon. Memb., p. 183.  
 1916. *Entylia emarginata* VanDuzee, Check List Hem., p. 62.

Guatemala (Butler, 1877); Senahu, San Juan, Chicam, San Geronimo, Las Mercedes, Zapote, Guatemala City (Champion, 1895); Guatemala City (W. D. F., 1942).

**Polyglypta costata** Burmeister

1835. *Polyglypta costata* Burmeister, Handb. Ent., 2: 142.  
 1846. *Polyglypta pilosa* Fairmaire, Rev. Memb., p. 296.  
 1846. *Polyglypta nigriventris* Fairmaire, Rev. Memb., p. 297.  
 1846. *Polyglypta viridimaculata* Fairmaire, Rev. Memb., p. 298.  
 1851. *Polyglypta interrupta* Walker, List Hom. B. M., p. 545.  
 1851. *Polyglypta straminea* Walker, List Hom. B. M., p. 544.  
 1858. *Polyglypta strigata* Walker, List Hom. B. M. Suppl., p. 136.  
 1859. *Polyglypta bogotensis* Dohrn, Cat. Hem., p. 79.  
 1877. *Polyglypta reflexa* Butler, Cist. Ent., 2: 207.  
 1880. *Polyglypta godmani* Distant, Ent. Month. Mag., 16: 11.

Guatemala (Salle, 1877); San Geronimo, El Jicaro, El Reposo, Las Mercedes, Cerro Zunil, Capetillo (Champion, 1895); San Jose (W. D. F., 1942).

**Polyglypta dorsalis** Burmeister

1836. *Polyglypta dorsalis* Burmeister, Rev. Silb., 4: 178.  
 1836. *Polyglypta maculata* Burmeister, Rev. Silb., 4: 178.  
 1836. *Polyglypta pallipes* Burmeister, Rev. Silb., 4: 179.  
 1843. *Polyglypta sciculata* Amyot and Serville, Hem., p. 541.  
 1843. *Polyglypta flavomaculata* Amyot and Serville, Hem., p. 541.  
 1877. *Polyglypta hordacea* Butler, Cist. Ent., 2: 209.  
 1877. *Polyglypta fusca* Butler, Cist. Ent., 2: 209.  
 1877. *Polyglypta tricolor* Butler, Cist. Ent., 2: 209.

Guatemala (Salle, 1877); Chicam, San Joaquin, San Geronimo, Mirandilla, Capetillo (Champion, 1895); Guatemala City (W. D. F., 1942).

**Polyglypta lineata** Burmeister

1836. *Polyglypta lineata* Burmeister, Rev. Silb., p. 179.  
 1846. *Polyglypta tredecem-costata* Fairmaire, Rev. Memb., p. 299.  
 1858. *Polyglypta abbreviata* Walker, List Hom. B. M. Suppl., p. 136.

Guatemala (Salle, 1877); San Joaquin, Vera Paz (Champion, 1895).

**Polyglypta nigella** Fairmaire

1846. *Polyglypta nigella* Fairmaire, Rev. Memb., p. 298.

Guatemala (Funkhouser collection, collector and date unknown).

**Polyglypta nigradorsis** Fowler

1896. *Polyglypta nigradorsis* Fowler, B. C. A., p. 123; Tab. 8, figs. 4, 4a.

Guatemala (Mus. Roy. Belg.); San Juan, San Geronimo, Vera Paz (Champion, 1895); Masagua (W. D. F., 1942).

***Polyglyptodes cucullatus* Fowler**

1896. *Polyglyptodes cucullatus* Fowler, B. C. A., p. 128; Tab. 8, figs. 10, 10a, 10b.  
Guatemala City (Champion, 1895; W. D. F., 1942).

***Polyglyptodes scaphiformis* Fowler**

1896. *Polyglyptodes scaphiformis* Fowler, B. C. A., p. 129; Tab. 8, figs. 11, 11a, 11b.  
Cerro Zunil (Champion, 1895).

***Vanduzea albifrons* Fowler**

1895. *Hypamastris albifrons* Fowler, B. C. A., p. 93; Tab. 6, figs. 24, 24a.  
1923. *Vanduzea albifrons* VanDuzee, Calif. Acad. Sci., 12: 11.

San Geronimo (Champion, 1895).

***Vanduzea segmentata* Fowler**

1895. *Hypamastris segmentata* Fowler, B. C. A., p. 93; Pl. 6, figs. 23, 23a, 23b.  
1908. *Vanduzea segmentata* VanDuzee, Stud. N. A. Memb., p. 103.

El Tumbador, San Isidro (Champion, 1895).

***Vanduzea mayana* sp. nov.**

(Figure 15)

Brown with white markings, finely punctate, densely pubescent; dorsum rounded, slightly depressed in center; posterior process reaching base of terminal cell of tegmen; tegmina partly concealed by pronotum, veins heavy and black; under surface brown and black; legs ferruginous, marked with black.

Head subquadrate, wider than long, black, smooth, not punctate nor pubescent; base nearly straight; eyes yellow with brown vertical bands; ocelli prominent, pearly, twice as far from each other as from the eyes and situated about on a line drawn through centers of eyes; a yellow spot under each ocellus; inferior margins of genae sloping, rounded; clypeus extending for one-third its length below inferior margins of genae, tip rounded and pilose.

Pronotum low, rounded, somewhat depressed in center, finely punctate, densely pubescent; anterior half dark brown, posterior half lighter; a white line on margins of humeral angles, a broad white band above humeral angles, a thin white transverse line extending from margin of pronotum upward just behind middle; sides of meso- and metathorax white; metopidium sloping, wider than high, a narrow white line above each eye; humeral angles short, triangular, blunt; median carina percurrent; posterior process heavy, blunt, extending to base of terminal cell of tegmen.

Tegmina half concealed under pronotum; hyaline with veins heavy and black; base narrowly coriaceous and punctate; five apical and four discoidal cells; base of third apical cell truncate; apical limbus broad.

Under surface of body black in front and light brown behind. Femora black; tibiae white with brown extremities; tarsi white with brown markings.

Length from front of head to tips of tegmina 4.2 mm.; width between humeral angles 2.2 mm.

Described from a single male taken at Chichicastenango, Guatemala, on February 23, 1942. Type in author's collection.

### Subfamily Centrotinae

#### **Campylocentrus brevicornis** Fowler

1896. *Campylocentrus brevicornis* Fowler, B. C. A., p. 151; Tab. 9, figs. 13, 13a.

Sinanja, Vera Paz (Champion, 1895).

#### **Campylocentrus curvidens** Fairmaire

1846. *Centrotus curvidens* Fairmaire, Rev. Memb., p. 515.

1846. *Centrotus subspinosus* Fairmaire, Rev. Memb., p. 519.

1866. *Acanthopis curvidens* Stål, Hem. Afr., 4: 89.

1894. *Campylocentrus subspinosus* Goding, Cat. Memb. N. A., p. 473.

1896. *Sphaerocentrus curvidens* Fowler, B. C. A., p. 154; Tab. 9, figs. 17, 17a, 17b.

Coban, San Geronimo, El Reposo, Las Mercedes, San Isidro, Pantaleon (Champion, 1896).

#### **Campylocentrus hamifer** Fairmaire

1846. *Centrotus hamifer* Fairmaire, Rev. Memb., p. 512.

1858. *Centrotus niveiplaga* Walker, List. Hom. B. M. Suppl., p. 160.

1869. *Campylocentrus hamifer* Stål, Bid. Memb. Kan., p. 289.

Guatemala (Scherzer, 1851); Sabo, Cerro Zunil (Champion, 1896).

#### **Campylocentrus vitreipennis** Fowler

1896. *Campylocentrus vitreipennis* Fowler, B. C. A., p. 150.

Senahu, Vera Paz (Champion, 1896).

#### **Endoiastus caviceps** Fowler

1896. *Endoiastus caviceps* Fowler, B. C. A., p. 168; Tab. 10, figs. 16, 16a.

Panzos, Cubilguitz (Champion, 1896).

#### **Gnamptocentrus cavipennis** Fowler

1896. *Gnamptocentrus cavipennis* Fowler, B. C. A., p. 153; Tab. 9, figs. 15, 15a, 15b.

1903. *Campylocentrus cavipennis* Buckton, Mon. Memb., p. 242.

Sinanja, Vera Paz (Champion, 1896).

#### **Gnamptocentrus sinuatus** Fowler

1896. *Gnamptocentrus sinuatus* Fowler, B. C. A., p. 152.

1903. *Campylocentrus sinuatus* Buckton, Mon. Memb., p. 242.

Cubilguitz, San Juan, El Tumbador, Las Mercedes, Cerro Zunil, Zapota (Champion, 1896).

#### **Microcentrus pileatus** Fowler

1896. *Phaulocentrus pileatus* Fowler, B. C. A., p. 159; Tab. 10, figs. 1, 1a.

1927. *Microcentrus pileatus* Funkhouser, Cat. Memb., p. 445.

San Geronimo (Champion, 1896).

#### **Microcentrus proximus** Fowler

1896. *Phaulocentrus proximus* Fowler, B. C. A., p. 160; Tab. 10, figs. 2, 2a.

1927. *Microcentrus proximus* Funkhouser, Cat. Memb., p. 445.

Cerro Zunil (Champion, 1896).

***Smerdalea horrescens* Fowler**

1896. *Smerdalea horrescens* Fowler, B. C. A., p. 163; Tab. 10, figs. 7, 7a, 7b.

Panzos, Vera Paz (Champion, 1896).

***Tolania obtusa* Fowler**

1896. *Tolania obtusa* Fowler, B. C. A., p. 166; Tab. 10, figs. 14, 14a.

Sinanja, Cubilguitz (Champion, 1896).

***Tolania opponens* Walker**

1858. *Centrotus opponens* Walker, List Hom. B. M. Suppl., p. 159.

1896. *Tolania opponens* Fowler, B. C. A., p. 166.

Sinanja, Chicam, Cubilguitz (Champion, 1896).

THE ECOLOGY OF THE ORTHOPTERA AND DERMAPTERA OF THE GEORGE RESERVE, MICHIGAN, by IRVING J. CANTRALL. Pages 1-182, 10 plates, 3 text figures, and 2 maps; 6 $\frac{3}{8}$  x 10 inches, paper bound. Miscellaneous Publications, Museum of Zoology, University of Michigan, No. 54. Published by UNIVERSITY OF MICHIGAN PRESS, Ann Arbor, Michigan. 1943. Price, \$1.50.

This paper presents the results of a three-year study of an area of about two square miles in Livingston County, Michigan. The study was made to determine the species present, their habitat relationships, the seasonal changes in their populations, to develop a classification of the orthopteran habitats, and to acquire information on the natural history of the species in the area.

The author's treatment of this subject may be indicated by the table of contents: Introduction (pp. 11-14), Methods of Study (pp. 15-26), Description of the Area (pp. 27-33), The Orthopteran Habitats of the Reserve (pp. 34-57), Seasonal Relationships of the Orthoptera (pp. 58-66, Tables II-XI), Annotated List of Orthoptera and Dermaptera (pp. 67-175), Summary and Conclusions (pp. 176-177), References (pp. 177-182), and Plates (I-X, twenty photographs of habitats in the Reserve).

The environments of the George Reserve are described in terms of their physiographic, pedologic, and phytologic characteristics, which are correlated with species distributions. The orthopteran habitats are classified into three major types: xeric (two habitats in the upland grasslands), mesoxeric (two habitats in the upland woodlands), and hydric (eight habitats in marsh, swamp, and bog); several strata are recognized, which extend through two or more habitats.

One species of Dermaptera and 75 species and races of Orthoptera (including four new to Michigan) are recorded from the area. The habitat relationships of these species are discussed in detail, and the occurrence of each species in different habitats is classified as characteristic, sporadic, or erratic, on the basis of the permanency of its occupation of the habitat. Some species were found to be restricted to particular habitats or strata, and others were found to shift with the seasonal progression; many species were found to spread as erratics into non-characteristic habitats, especially in the fall. The relative abundance of the orthopteran populations, which was estimated from extensive field observations and collecting, is recorded on a five-term scale (abundant, common, numerous, occasional, or rare). A large amount of data on the life history, seasonal relations, breeding habits, song, etc., is given in the accounts of individual species.

This is a very comprehensive treatment of the subject. The author has presented in a clear and concise form a considerable amount of data on orthopteran ecology obtained by field and laboratory observations. This paper should be of interest not only to orthopterists, but to all entomologists interested in ecology. Entomological literature would be greatly enriched by more papers like this one.—D. J. B.

# SOME VITAMIN REQUIREMENTS OF BLACK CARPET BEETLES, *ATTAGENUS* (?) SPP.

(Coleoptera: Dermestidae)

WARREN MOORE,<sup>1</sup>

Bon Air, Va.

Nutritionists are using numerous pure chemicals and purified substances in studying the nutrition of vertebrates. Additional nutritives have been discovered by micro-biologists. It was believed that black carpet beetle larvae could be fed most of the substances which have been used in studying the nutrition of other organisms.

A study of the growth of the larvae in synthetic rations was begun in January, 1941. The insects came from pure cultures of our two species.<sup>2</sup> Some seven hundred growth studies have been made to date, but many of them have only served to indicate defects in my technique. Growth is determined not only by the chemical composition of the ration, but is influenced also by physical factors such as hardness, dustiness, and moisture content. These factors, in turn, are influenced by chemical composition. For example, at low humidity, the addition of 15% glycerol resulted in increased growth, the ration being less dusty and presumably having a higher moisture content. At high humidity, the ration containing glycerol became sticky and the insects grew faster when glycerol was omitted. In studying five of the vitamins, I have succeeded in preparing rations which seemed to differ only in chemical composition. Some experiments with these rations will be reported in this paper.

## VITAMIN TESTS

The ration had approximately the following composition:

1. Vitamin-free casein (Labco)	350.0 mg.
2. Corn starch (Argo)	150.0 mg.
3. Mineral mixture... .	15.0 mg.
4. Benzene extract of liver <sup>3</sup>	0.025 c. c.
5. Extracted fish meal	30.0 mg.
6. Glycerol.	70.0 mg.
7. Choline chloride	1.000 mg.
8. Nicotinic acid (Niacin)	0.050 mg.
9. Thiamin Chloride (B <sub>1</sub> )	0.007 mg.
10. Riboflavin (B <sub>2</sub> )	0.005 mg.
11. Pyridoxin HCl (B <sub>6</sub> )	0.006 mg.
12. Ca pantothenate (Pan)	0.020 mg.
13. Mead's Oil of Percomorpheus	5.0 mg.
14. Cystine.....	2.0 mg.
15. Glucosamine HCl	2.0 mg.

<sup>1</sup>Acknowledgments are due to Dr. J. C. Forbes and to Dr. W. A. Peabody, of Richmond, for advice and for materials, and to M. B. Moore for handling the cultures and other help.

<sup>2</sup>Moore, Warren and Moore, M. B. 1942. Two species of black carpet beetle. J. Ec. Ent., 35: 288.

<sup>3</sup>100 c. c. contained the extract from 100 gm. of liver meal.



16. Urea.....	2.0 mg.
17. Phytin.....	1.0 mg.
18. B-alanine.....	0.012 mg.
19. p-aminobenzoic acid.....	0.020 mg.

Of the ingredients, the first twelve are present because they seemed to be beneficial, the remaining seven for theoretical reasons. Newly-hatched larvae of both species grew slowly on this ration for at least seven weeks. When one of the vitamins was omitted, a mixture resulted which seemed not to differ physically from the complete mixture. A missing vitamin was restored by adding its alcoholic solution, mixing, and heating to 100° C.

TABLE I

INFLUENCE OF FIVE VITAMINS ON THE GROWTH OF BLACK CARPET BEETLE LARVAE (YELLOWs)

Number and weight in milligrams of the insects. \*\*\*\*indicates when the missing vitamin was restored.

ELAPSED TIME IN WEEKS	MISSING VITAMINS											
	B <sub>1</sub>		B <sub>6</sub>		B <sub>2</sub>		Nicotinic Acid		Panto- thenic Acid		None	
	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
0	25	(1.)	25	(1.)	25	(1.)	25	(1.)	25	(1.)	25	(1.)
3	25	5.6	25	5.7	14	2.5	25	3.4	7	1.5	22	6.1
4	24	7.1	25	7.5	13	2.5	25	3.4	7	1.7	22	8.5
5	23	8.0	25	8.9	12	3.7	22	5.1	5	1.6	23	13.6
6	22	8.3	24	9.4	12	6.5	22	7.7	5	2.2	23	14.8
7	21	8.2	23	9.4	11	9.0	22	10.0	5	2.2	23	18.1
8	21	9.6	21	12.0	.....	.....	.....	.....	5	3.4	23	20.5
9	20	11.7	21	12.4	11	11.2	21	13.0	5	4.4	23	20.6
10	.....	.....	19	14.2	.....	.....	.....	.....	.....	.....	23	21.7

Table I shows a comparison of the growth and mortality of newly-hatched "yellows," *Attagenus? piceus?* 220 mg. of feed and 25 larvae were placed in each of six shell vials. They were kept in an incubator at 86°-87° F. and about 60 per cent R. H., except when they were removed for observation and manipulation. At intervals, the larvae were separated by sifting, counted, weighed, and returned to the food and vials from which they had been removed. When growth ceased in a vial, the missing vitamin was restored by adding a drop of its alcoholic solution.

A similar test with newly-hatched larvae of the "blacks" yielded similar results. When any one of the five vitamins was omitted, growth ceased in four to six weeks. When the missing vitamin was restored, growth was resumed. In the complete ration, growth continued throughout the experiment.

The data indicate that newly-hatched larvae of neither species can grow on diets which do not supply thiamin, riboflavin, pyridoxin, nicotinic acid, and pantothenic acid. B-alanine did not replace pantothenic acid. Whether other vitamin fragments are active has not been determined.

It will be noted that the insects receiving all five vitamins were heavier at each successive weighing. When any of the five vitamins was omitted, growth ceased sooner or later, and was resumed when the missing vitamin was supplied.

### SUMMARY

Newly-hatched larvae of two species of black carpet beetle grew slowly in a synthetic ration containing vitamin-free casein, starch, minerals, extracted fish meal, benzene extract of liver, glycerol, choline, nicotinic acid, thiamin, riboflavin, pyridoxin, and pantothenic acid. When any one of the last five was omitted, growth ceased sooner or later and was resumed when the missing vitamin was supplied.

**ECOLOGICAL CROP GEOGRAPHY**, by KARL H. W. KLAGES. Pages xviii+615, 108 figures, 6 x 9½ inches. Published by THE MACMILLAN CO., New York, N. Y. 1942. Price, \$4.50.

Entomologists who are aware of the importance of an understanding of plant ecology to an understanding of insect problems will find in this book a clear, comprehensive, and up-to-date treatment of the principles underlying the ecology and distribution of crop plants. Although the book was written primarily for students of agronomy, it will fill a long-felt need by biologists, economists, geographers, and others who are interested in the problems of crop ecology.

The book is divided into four parts. Part I (pp. 1-70), *The Social Environment of Crop Plants*, discusses the economic, political, social, technological, and historical factors which influence crop plants; these factors are either omitted or treated but slightly in most plant ecology texts. Part II (pp. 71-131), *The Physiological Environment of Crop Plants*, deals with the general aspects of the interactions of the plant with environmental factors (external factors in relation to development, physiological limits, crop yields and the ecological optimum, and adaptation). Part III (pp. 132-338), *The Ecological Factors*, contains detailed discussions of moisture and moisture relationships, temperature, light, air movement, edaphic and physiographic factors, and contains a chapter on climate classifications. Part IV (pp. 339-594), *The Geographical Distribution of Crop Plants*, emphasizes the physiological growth requirements of the crop plants discussed rather than the statistical phases of the subject.

The material in this book is well organized and clearly presented. At the end of each chapter is a list of selected references, and at the end of the book is an author index and a subject index. The statistical data cited (and shown by numerous tables and maps) were obtained from the United States Department of Agriculture, *Agricultural Statistics*, 1940.

We heartily recommend this book to entomologists and others who are interested in the phase of plant ecology which has to do with crop plants.—D. J. B.

# THE TAXONOMY OF THE FALSE SCORPION GENUS SYNSPHYRONUS WITH REMARKS ON THE SPORADIC LOSS OF STABILITY IN GENERALLY CONSTANT MORPHOLOGICAL CHARACTERS

(Arachnida: Chelonethida)

JOSEPH C. CHAMBERLIN,<sup>1</sup>

Forest Grove, Oregon

The genus *Synsphyronus* Chamberlin was erected in 1930 (Ann. and Mag. Nat. Hist. (10), 5 : 609, 616-617) to accommodate an unusual species of the family Garypidae which differed primarily from other members of the group in having the metatarsus and tarsus of the legs secondarily fused to form a typical miotarsus. At the time, it was pointed out that, in spite of this unusual character, the genus was undoubtedly truly referable to the family Garypidae on the basis of every other morphological character definitive of that group. In spite of this, Beier in 1932 (Das Tierreich, 57 : 238) elevated the genus to family rank (Synsphyronidae) and removed it from the superfamily Garypoidea<sup>2</sup> to the Feaelloidea. Consideration of the following tabular summary of the normal characteristics of these two superfamilies will clearly reveal the untenability of Beier's disposition of this genus. In every character but the invariable presence of a normal, two-segmented tarsus, *Synsphyronus* agrees with the characters itemized under the heading Garypoidea.

## GARYPOIDEA

Tarsus two-segmented.  
Carapacial alae or abdominal pleural plates absent.  
Venom apparatus present in both fingers.  
Femoral articulation of leg IV a strongly oblique symphysis.  
Leg I structurally strongly differentiated from leg IV.  
Lamina exterior present.  
Posterior maxillary lyrifissure present.  
Anus terminal or at most subventral; the eleventh tergite distinct.

## FEAELLOIDEA

Tarsus one-segmented.  
Either carapacial alae or abdominal pleural plates present.  
Venom apparatus completely lacking.  
Femoral articulation of leg IV freely mobile as in leg I.  
Leg I superficially scarcely differentiated from leg IV.  
Lamina exterior absent.  
Posterior maxillary lyrifissure absent.  
Anus ventral; the eleventh tergite fused with the eleventh sternite to form a ventral circumanal plate.

<sup>1</sup>Associate Entomologist, Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture, Forest Grove, Oregon.

<sup>2</sup>Beier in his monograph of 1932 (*op. cit.*) took occasion to rename all the suborders and superfamilies proposed by Chamberlin in 1929 and 1931 without any significant change in the concept of the categories so considered. Thus the suborder Heterosphyronida of Chamberlin became the suborder Chthoniinea Beier, the Diplosphyronida the Neobisiinea Beier, and the Monosphyronida the Cheliferinea Beier. In the case of the superfamilies a change in the termination of the name from *-oidea* to *-ides* (e. g., Chthonioidea to Chthoniides) was taken as the occasion for the erection of six "new" superfamilies. The justification

Finally, the accession of additional material representing two new species, hereinafter described, provides specimens which clearly show every step in gradation between the normally differentiated metatarsus and telotarsus of the usual garypid leg and the miotarsus of *Synsphyronus*.

At the time of its original description (Chamberlin, *op. cit.*) it was pointed out that *Synsphyronus* was closely related, in a generic sense, to *Maorigarypus*. This is borne out by the present study, which indicates the necessity of so redefining the generic limits of *Synsphyronus* as to involve the reduction of *Maorigarypus* either to synonymy or to sub-generic status. The latter course is here followed. Although both these names were published at the same time, *Synsphyronus* has page priority and will therefore stand as the name of the genus.

The instability of the tarsal segmentation in this genus, a character which is otherwise subordinally constant, is of interest, but is by no means unique in arthropod morphology. For example, the number of tarsal segments has been employed as a primary character in the division of the coleopterous subfamily Aleocharinae into tribes. Nevertheless, as shown by Chamberlin and Ferris (Pan-Pacific Ent. 5 (3) : 142, 1929), material of the single species *Diaulota brevipes* Casey yielded individuals with clearly four-segmented tarsi while in others the tarsi were as clearly five-segmented. Furthermore, gradations between these two extremes were available (Chamberlin and Ferris, *op. cit.*, p. 160, fig. 3E, 3G).

As a further example illustrating the sporadic instability of a generally constant characteristic, we may note that the movable finger of all chelonethids characteristically bears but a single seta (the galeal seta). Rarely two or three galeal setae may occur teratologically in individual specimens but never consistently except in the five species comprising the genus *Ellingsenius* (Cheliferidae, Cheliferinae) and in the unique species of the genus *Corosoma* (Chernetidae). In these two unrelated genera three galeal setae are normally present.

Such examples could be indefinitely multiplied and some must occur to most workers familiar with almost any extensive group.

This sporadic break-down of generally constant characters provides certain discouraging but nevertheless interesting features in the problems of taxonomy and emphasizes the need of classifications based on other than single characters, at least if a phylogenetically natural grouping is to be maintained. On the other hand, such a break-down must not be construed as proof that the character in question is of general instability elsewhere, and hence not to be regarded as reliable in any group. A character which may be of such constancy in many groups as actually to define categories of family or superfamily rank may be of only generic or specific value in other groups such as the present genus.

It is of further interest to note that in *Synsphyronus* the presence or absence of certain tactile setae of the chela is likewise generically unstable

for this action has never been published but the synonymy of the names so proposed, with those previously validated by the writer, is self-evident. The use of these names should therefore be eliminated from future taxonomic literature. There is already sufficient difficulty in achieving nomenclatorial stability without the introduction and use of a parallel series of names for identical taxonomic categories of whatever rank.

and of no more than specific value, whereas in most chelonethids the number and pattern of these setae are of generic or even greater constancy.

## SUPERFAMILY Garypoidea Chamberlin

### Family Garypidae Hansen

#### Subfamily Garypinae Simon

#### Genus *Synsphyronus* Chamberlin

1930. *Synsphyronus* + *Maorigarypus* Chamberlin, Ann. and Mag. Nat. Hist. (10) 5: 616-617.  
 1931. *Synsphyronus* + *Maorigarypus* Chamberlin, Stanford Univ. Pubs., Univ. Ser., Biol. Sci. 7 (1): 135, 153, 155, 208, 215, and 228 (figs.).  
 1932. *Synsphyronus* Chamberlin + *Synsphyronidae* Beier + *Maorigarypus* Chamberlin, Beier, Das Tierreich, 57: 238 and 226.

*Orthotype*.—*Synsphyronus paradoxus* Chamberlin.

*Distribution*.—New Zealand and Australia.

*Diagnosis* (emended).—Garypine genus of typical facies most closely allied to *Anagarypus* Chamberlin. Carapace of usual form; transverse furrows absent or at most a posterior furrow very weakly developed; eyes large and conspicuous and about 3.5-4 ocular diameters from anterior margin (figs. 4, 6). Arolium extending beyond tarsal claws (figs. 12, 13); vestitural setae straight and distinctly to prominently clavate (figs. 5, 14); tergites with a marginal series of 4-10 setae and 8-16 large and relatively conspicuous lyrifissures; tergite 1 entire, 2-10 divided by a narrow stripe, 11 entire or partially divided; basifemur of legs I and II subequal to or slightly longer than telofemur (figs. 15, 16); femoral articulation of legs I and II semi-mobile (figs. 15, 16); tarsal segmentation variable; some species with a miotarsus, others with metatarsus and telotarsus distinct (figs. 18, 19, 20); all gradations between the two and single segmented tarsus occurring rarely on the same specimen (especially in *Synsphyronus* (*S.*) *mimetis* and *S.* (*M.*) *mimulus*, spp. nov.). Chaetotaxy (fig. 9) of chela generically unstable, the total number of tactile setae varying from 8 to 9 on the fixed finger and from 1 to 3 on the movable finger. Seta T of movable finger always present; SB and ST present or absent; B always absent. The eight tactile setae of the interior and exterior series present and, in addition, an accessory tactile seta ("A") sometimes occurring slightly caudad of IT (fig. 9). In as far as it is not affected by the loss of setae, the chaetotaxy of the various included species conforms closely to the theoretically complete pattern shown herewith (fig. 9). Only seta B of the movable finger seems to be consistently absent in all species. The chaetotaxy differs from that of *Anagarypus* in that seta EST in that genus is only slightly proximad of IT but is much posterior thereto in *Synsphyronus* (IT nearer to EST than to ET in *Anagarypus* but much closer to ET than to EST in *Synsphyronus*). Chelicera of usual facies; galeal seta apical in position and opposite distal attachment of serrula exterior (fig. 11);

seta *sb* nearly opposite seta *is* and together with *ls* forming a compact triangular group (fig. 11); setae *b* and *es* both present and normal in position; setae *b* and *sb* unusually short. Flagellum with three blades (figs. 10, 11). Hand of chela broader than deep. Derm of palps, carapace, tergites, and legs reticulately rugose, the reticulations occurring in a more or less conspicuous, hyaline pseudoderm which is separable from the true derm but which normally invests it closely as a tunic (figs. 5, 8, 17, 25-30). When removed (mechanically or otherwise) the true derm is nearly or quite smooth although usually retaining the appearance of the reticulations, on tergites and carapace, as smooth tessellations. The setae are not removed by peeling the pseudoderm, either mechanically or by boiling in caustic potash. No pores or glands have been observed from which this pseudoderm might be derived. It is generally thin or absent from around the setae. The presence of this pseudoderm, which has earlier been noted by With, is not confined to *Synsphyronus* but also occurs in *Anagarypus*, at least.

*Remarks.*—It is to be noted that the interpretation of the homologies of the tactile setae of the chela in this genus as given in this study (see figs. 9, 21-24) differs from that indicated by Chamberlin in 1931 (*op. cit.*, p. 141, fig. 37S), which is now regarded as in error.

The measurements and proportions given in connection with the specific descriptions are exclusive of the pseudoderm.

The species *Garypus hansenii* With from Tasmania was assigned to this genus in 1932 by Beier (*op. cit.*). It differs widely, however, in a number of important respects which, I believe, are sufficient to justify its removal from the group. A new genus, *Idiogarypus*, q. v., is therefore erected at this time for its reception.

Excluding *hansenii*, five species are currently referable to the genus. These may be separated by means of the following key:

1. Tarsi single-segmented (point of intertarsal union sometimes visible as a more or less definite constriction which is, however, nonmembranous), (Subgenus *Synsphyronus*)..... 2
2. Tarsi two-segmented (occasionally one or two of the legs of certain specimens will have the intertarsal articulation vestigial, in which case three tactile setae occur on the movable finger of the chela), (subgenus *Maorigarypus*)... 3
2. Movable finger with two tactile setae; anterior eyes strongly elliptical; robust species, femur 3.46-3.60 times as long as broad..... **paradoxus**
- Movable finger with but a single tactile seta; anterior eyes circular; slender species, femur 3.8-4.1 times as long as broad..... **mimetus**
3. Movable finger of chela with one, fixed finger with nine, tactile setae..... 4
- Movable finger with three, fixed finger with eight, tactile setae..... **mimulus**
4. Tibia of female 2.8 (male 2.6) times as long as broad; femur of female 4.3 (male 4.1) times as long as broad; female galea with three terminal branches; male 3.4, female 4.0 mm. long; median tergites bordered by 6-8 clavate setae; palpal chela much more darkly pigmented than the other segments and blackish in color; green coloration not evident on preserved specimens at least; from New Zealand..... **melanocheilatus**
- Tibia of female about 2.5 times as long as broad; femur of female 4.0 times as long as broad; female galea with two terminal branches; female 2.8 mm. long; median tergites bordered by four clavate setae; light green in color—not noted whether this was in life and whether or not it is retained after preservation; palps presumable unicolorous (not specifically noted as otherwise); from Australia..... **viridis**

Subgenus *Synsphyronus* Chamberlin

*Previous references*.—Heretofore considered of full generic rank. See literature citations under generic heading.

*Orthotype*.—*Synsphyronus paradoxus* Chamberlin.

*Diagnosis*.—Tarsal segments of legs secondarily fused into a more or less typical miotarsus.

*Synsphyronus* (*Synsphyronus*) *paradoxus* Chamberlin

Figures 2, 24, 29, 30

1930. *S. paradoxus* Chamberlin, Ann. and Mag. Nat. Hist. (10) 5: 617 (tf. 1-BB, CC legs I and IV and 3 V palpal seta).  
 1931. *S. paradoxus* Chamberlin, Chamberlin, Stanford Univ. Pubs., Univ. Ser., Biol. Sci. 7 (1): 52, fig. 11, I (ventral aspect of cheliceral foramina); 122, fig. 29 E (pedipalp); 164, figs. 44, D, C, (legs I and IV); 177, figs. 47, M, P (setae of tergite and pedipalp).  
 1932. *S. paradoxus* Chamberlin, Beier, Das Tierreich, 57: 238.  
 1937. *S. paradoxus* Chamberlin, Tubb, Roy. Soc. Victoria, Proc. (n. s.), 49: 412-419.

*Diagnosis* (addenda on basis of types).—Anterior eyes strongly elliptical rather than circular (fig. 2). Chaetotaxy of chelicera typical of subfamily; flagellum of three blades, the posterior two of which are much dwarfed. Serrula exterior with 15 teeth. Fixed finger of chelicera with three large, median, and two small, subapical, marginal teeth. Fixed finger of chela with 34, movable finger with 27, marginal teeth; in both cases the proximal 4-6 teeth are reduced and nearly obsolescent. Chaetotaxy of chela (fig. 24) conforming closely to the generic pattern as far as present; setae A, ST, and SB absent (fig. 24). Carapacal chaetotaxy 2-6 (30-34); median disc of carapace with a total of 10-14 setae; tergites 1-3 bordered by 6-8 setae while tergites 4-9 are bordered by 9 or 10 (generally the latter). Palpal form (male and female) as illustrated (figs. 29, 30).

*Proportions*.—The following appendicular proportions are those of the holotype and allotype (i. e., male and female), respectively. Palps:

## EXPLANATION OF PLATE I

FIGURE 1, *Synsphyronus* (*Maorigarypus*) *mimulus*, eyes; 2, *S. (S.) paradoxus*, eyes (note elliptical form of anterior eye), (female 481.02002); 3, *S. (S.) mimetus*, eyes; 4, *S. (M.) mimulus*, carapace and anterior tergites (male 619.03008); 5, *S. (M.) mimulus*, hyaline pseudoderm and vestitural seta from palpal tibia (male 619.03001); 6, *S. (S.) mimetus*, carapace and anterior tergites (female 619.02005); 7, *S. (M.) mimulus*, tip of fingers of chela (movable and fixed fingers, left and right, respectively), (male 619.03003); 8, *S. (S.) mimetus*, hyaline pseudoderm showing reticulations (removed from palpal tibia) (male 619.02007); 9, *Synsphyronus*, pattern of hypothetically complete chaetotaxy of the chela, based on form of *S. (S.) mimetus*; 10, *S. (S.) mimetus*, flagellum (male 619.02008); 11, *S. (S.) mimetus*, chelicera; 12, *S. (S.) mimetus*, fourth leg; 13, *S. (M.) mimulus*, fourth leg; 14, *S. (M.) mimulus*, tibial seta from fourth leg; 15, *S. (S.) mimetus*, first leg; 16, *S. (M.) mimulus*, first leg (female 619.03002); 17, *S. (M.) mimulus*, hyaline pseudoderm and setae on exterior aspect of palpal femur (female 619.02004); 18, *S. (S.) mimetus*, fourth tarsus showing vestigial articulation between metatarsus and telotarsus (female 619.02004); 19, *S. (M.) mimulus*, fourth tarsus showing normal metatarsus and telotarsus; 20, *S. (S.) mimetus*, fourth tarsus showing suppression of intertarsal articulation with resultant formation of a typical miotarsus (male 619.02001).





Trochanter 1.14 times as long as broad; femur about as long as carapace, 3.46–3.60 times as long as broad; tibia about as long as hand and much shorter than femur, 2.47–2.39 times as long as broad; chela 3.42–3.45 times as long as broad; hand and fingers subequal in length; hand 1.77–1.71 times as long as broad. Leg IV: Femur (greatest length of both subsegments) 2.91–3.47 times as long as deep and longer than palpal tibia; tibia 3.38–3.67 times as long as deep; miotarsus 3.62–3.65 times as long as deep. Leg I: Femur (both subsegments) 2.57 times as long as deep; tibia 2.64–2.52 times as long as deep; miotarsus 3.54–3.45 times as long as deep.

*Measurements* (in mm.).—Male (holotype). Total length (KOH cleared) 2.67, abdominal breadth 1.4. Carapace 0.787 long, 0.902 broad posteriorly, 0.541 broad across eyes. Cucullus 0.213 long. Palps: Trochanter 0.336 by 0.295, femur 0.754 by 0.220, tibia 0.582 by 0.236; chela 1.123 by 0.328, hand 0.585 long, fingers 0.559 long. Leg I: Femur (both subsegments) 0.371 by 0.144, basifemur 0.180 long, telofemur 0.208 long, tibia 0.243 by 0.092, miotarsus 0.230 by 0.065. Leg IV: Femur (greatest length both subsegments) 0.609 by 0.208, tibia 0.377 by 0.112, miotarsus 0.297 by 0.082.

Female (allotype). Total length (KOH cleared) 2.96, abdominal breadth 1.6. Carapace 0.768 long, 1.00 broad posteriorly, and 0.51 broad across eyes. Cucullus 0.180 long. Palps: Trochanter, indet., femur 0.786 by 0.218, tibia 0.587 by 0.246, chela 1.189 by 0.344, hand 0.620 long, fingers 0.590 long. Leg I: Femur (both subsegments) 0.379 by 0.148; basifemur 0.180 long, telofemur 0.215 long, tibia 0.248 by 0.098, miotarsus 0.238 by 0.069. Leg IV: Femur (greatest length both subsegments) 0.643 by 0.185, tibia 0.403 by 0.110, miotarsus 0.312 by 0.085.

*Remarks*.—Known originally from a single collection of four specimens from an unknown habitat at Menindie, New South Wales, Australia. Tubb (*op. cit.*) has since recorded it as "abundant under stones on Lady Julia Percy Island, Victoria, Australia."

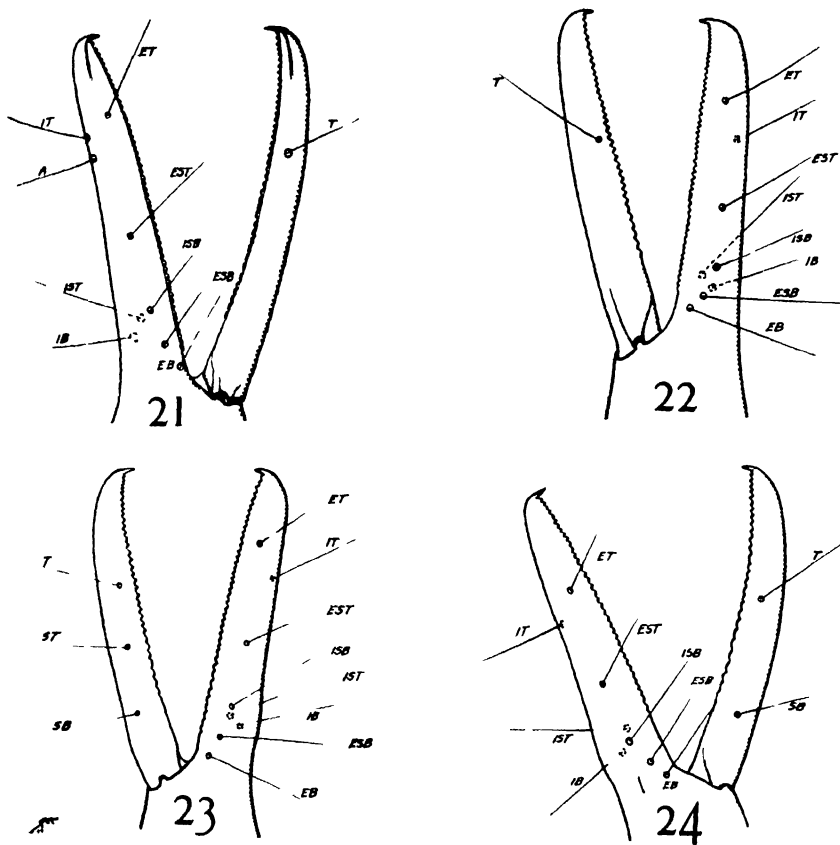
Types in author's collection.

### **Synsphyronus (Synsphyronus) mimetus**, sp. nov.

Figures 3, 6, 8, 10, 11, 12, 15, 18, 20, 22, 25, 27

*Type Material*.—Holotype male (JC-619.02001), allotype female (JC-619.02004), and paratopotype males, females, and nymphs (JC-619.02002–3 and 5–40). Same collection data as for *Synsphyronus* (*Maorigarypus*) *mimulus*, sp. nov.: Corney Point, York Peninsula, South Australia, near Adelaide (cf. p. 496). Collected by Dr. S. Hirst and donated to the author. Types in author's collection; paratypes to be deposited in the United States National Museum and in the Museum of the University of Utah.

*Diagnosis*.—Excessively close in facies and appendicular proportions to *Synsphyronus* (*Maorigarypus*) *mimulus*, sp. nov. Serrula exterior of chelicera with 16–18 teeth; fixed finger with three large, submedian, and two small, subapical, teeth. Movable finger of chela with 35–40 (generally nearer the latter), fixed finger with



# EXPLANATION OF PLATE II

FIGURE 21, *Synsphyronus (Maorigarypus) melanocheilatus* (from Chamberlin, 1931; modified); 22, *S. (S.) mimetus* (male 619.02001); 23, *S. (M.) mimulus* (male 619.03003); 24, *S. (S.) paradoxus* (male 481.02001).

47-54, marginal teeth which are well developed on both fingers to the base. Chaetotaxy of chela conforming closely to generic pattern as far as present (fig. 22); setae A, ST, SB, and B lacking. Carapace of usual form (fig. 6); transverse furrows absent or vestigial; anterior eyes nearly circular (fig. 3); chaetotaxy 2-4 (30-34). Tergal scuta with a central darker spot. Tergites 1-3 bordered posteriorly by four, tergites 4-9 by six, clavate setae and about 14 large lyrifissures. Sternites bordered by six acute (or elongate clavate (latter on posterior segments)) setae and about 14 large lyrifissures. Coxal area of typical garypoid type (Chamberlin, Stanford Univ. Pubs., Univ. Ser., Biol. Sci. 7(1): 84, fig. 19-J, 1931) except that the maxillae are relatively somewhat shortened and there is a slight tendency for the trochanteral foramen of the forelegs to assume a more ventral position than usual. Palps as illustrated (figs. 25, 27).

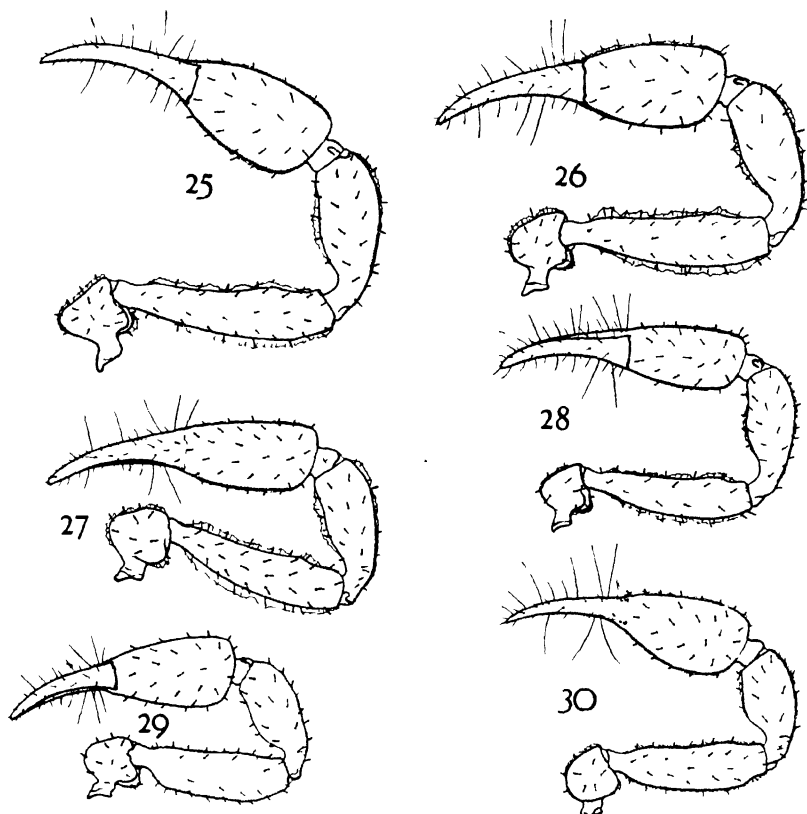
*Proportions* (limits of actually observed variation indicated).—Male: Trochanter 1.3-1.4 times as long as broad, femur 4.1 times as long as broad, tibia 2.7-2.8 times as long as broad, chela 3.8-4.2 times as long as broad, hand 1.8-2.1 times as long as broad, hand about equal to or slightly shorter than fingers. Female: Trochanter 1.3 times as long as broad, femur 3.9-4.0 times as long as broad, tibia 2.6-2.9 times as long as broad, chela 3.5-3.7 times as long as broad, hand 1.8-2.1 times as long as broad, hand shorter than fingers. Leg I (both sexes): Femur (both subsegments) 3.0-3.3 times as long as deep, tibia 2.8-3.0 times as long as deep, miotarsus 3.9-4.0 times as long as deep, basifemur slightly longer than telofemur. Telofemur deeper than basifemur. Leg IV (both sexes): Femur (greatest length both subsegments) 3.7-4.2 times as long as deep, tibia 4.3-4.7 times as long as deep, miotarsus 4.1-4.6 times as long as deep.

Constriction or pseudosuture of miotarsus of all legs (at point marking the fusion point of the two tarsal segments) submedian in position (figs. 18, 20).

*Measurements* (in mm.)—Male (holotype). Total length (KOH expanded) 2.79, abdominal width 1.6. Carapace 0.80 long, 0.935 broad posteriorly, and 0.517 broad across eyes. Cucullus 0.197 long. Palps: Trochanter 0.407 by 0.308, femur 0.918 by 0.226, tibia 0.695 by 0.253, chela 1.255 by 0.326, hand 0.604 long and 0.278 deep, fingers 0.671 long. Leg I: Femur (both subsegments) 0.453 by 0.148, tibia 0.290 by 0.098, miotarsus 0.271 by 0.069. Leg IV: Femur (greatest length both subsegments) 0.697 by 0.180, tibia 0.475 by 0.103, miotarsus 0.358 by 0.085.

Female (allotype). Total length (KOH cleared) 3.48, abdominal breadth 1.9. Carapace 0.92 long, 1.081 broad posteriorly, and 0.607 broad behind eyes. Cucullus 0.230 long. Palps: Trochanter 0.448 by 0.354, femur 1.046 by 0.261, tibia 0.804 by 0.279, chela 1.44 by 0.410, hand 0.689 long and 0.361 deep, fingers 0.772 long. Leg I: Femur (both subsegments) 0.522 by 0.157, tibia 0.328 by 0.110, miotarsus 0.315 by 0.080. Leg IV: Femur (greatest length both subsegments) 0.815 by 0.195, tibia 0.541 by 0.115, miotarsus 0.412 by 0.093.

Out of four specimens measured the following were the extremes (male and female) in the palpal measurements: Trochanter 0.407-0.448



EXPLANATION OF PLATE III

(All drawings to same scale.)

FIGURE 25, *Synsphyronus (Synsphyronus) mimetus*, ventral aspect of left pedipalp (female 619.02004); 26, *S. (Maorigarypus) mimulus*, ventral aspect of left pedipalp (female 619.03002); 27, *S. (S.) mimetus*, dorsal aspect of right pedipalp (male 619.02003); 28, *S. (M.) mimulus*, ventral aspect of left pedipalp (male 619.03001); 29, *S. (S.) paradoxus*, ventral aspect of left pedipalp (male holotype); 30, *S. (S.) paradoxus*, dorsal aspect of right pedipalp (female allotype).

by 0.303–0.354, femur 0.918–1.046 by 0.226–0.261, tibia 0.689–0.804 by 0.249–0.294, chela 1.255–1.446 by 0.310–0.410, hand 0.604–0.725 long, fingers 0.659–0.772. Total body length 2.79–3.48.

**Remarks.**—Disregarding the chaetotaxy of the chela and the presence or absence of the miotarsus, it is instructive to compare this form with the excessively similar *Synsphyronus* (*Maorigarypus*) *mimulus*. As will be noted in comparing the descriptions, aside from the features above mentioned, there is scarcely a sharply marked characteristic by which the two species may be separated. Palpal and pedal proportions especially are extremely close or identical. In the following couplet all the definite points of difference I have been able to find are contrasted:

1. Tarsi fused to form a miotarsus, showing at most a more or less definite constriction and suturelike marks at the point of the former articulation; movable finger with but a single tactile seta present (T); median disc of carapace with a total of 11–14 setae; tergites 4 and 5 with six border setae; palps slightly more robust than in the following species, chela of male 2.8–4.2, of female, 3.5–3.6 times as long as broad; miotarsi relatively stout, tarsi I 3.9–4.0 times, tarsi IV 4.1–4.6 times, as long as deep,

S. (S.) *mimetus*

Tarsi plainly two-segmented, only rarely being fused to form a miotarsus (and then this does not affect all the legs); movable finger of chela with three tactile setae, B only lacking; median disc of carapace with 6–8 setae; tergites 4 and 5 with four border setae; palps more attenuate, chela of male 4.2–4.4 times, of female 3.5–3.8 times, as long as broad; tarsi more slender, measuring both segments as a miotarsus, tarsi I 4.2–4.6 times, tarsi IV 4.7–5.0 times, as long as deep. . . . . S. (M.) *mimulus*

#### Subgenus *Maorigarypus* Chamberlin

**Previous references.**—Heretofore considered of full generic rank. See literature citations under the generic heading.

**Orthotype.**—*Maorigarypus melanochelatus* Chamberlin.

**Diagnosis.**—Tarsal segments of legs distinct, two in number.

#### *Synsphyronus* (*Maorigarypus*) *mimulus*, sp. nov.

Figures 1, 4, 5, 7, 13, 14, 16, 17, 19, 23, 26, 28

**Type Material.**—Holotype male (JC-619.03001), allotype female (JC-619.03002), and paratopotype male and female (JC-619.03003–28), all from the same collection vial labeled “Corney Point, York Peninsula, South Australia.” This locality is near Adelaide (137° west longitude and 35° south latitude). Collected by Dr. S. Hirst, to whom I am indebted for this splendid collection. This material was included in the same vial which contained the type lot of *Synsphyronus* (S.) *mimetus*, sp. nov. All material is in the author’s collection. Types in the author’s collection; paratypes to be deposited in the United States National Museum and in the Museum of the University of Utah.

**Diagnosis.**—Excessively close in most respects to *Synsphyronus* (S.) *mimetus*, sp. nov. Serrula exterior of chelicera with about 18 teeth; fixed finger with three large, submedian, and two small, sub-apical, teeth. Movable finger of chela with 32–37 and fixed finger with 44–51 marginal teeth, which are well developed to the base of the fingers. Chaetotaxy of chela as illustrated (fig. 23), setae A and

B only absent. Carapace of usual form; posterior furrow absent or very weakly defined; chaetotaxy 2-4 (24). Tergites bordered by 12-14 large lyrifissures in addition to the marginal setae which number four on segments 1-5, four or five on segment 6, and six on segments 7-9. Sternites similarly bordered by about the same number of acute to slenderly clavate (latter on posterior segments) setae and about 14 lyrifissures. Coxal area as in *S. (S.) mimetus*, sp. nov. (cf. p. 000). Palpal form as illustrated (figs. 26, 28).

*Proportions* (limits of actually observed variations indicated).—

Male: Trochanter 1.2-1.4 times as long as broad, femur 3.8-4.2 times as long as broad, tibia 2.9-3.1 times as long as broad, chela 4.2-4.4 times as long as broad, hand 1.9-2.0 times as long as broad, hand shorter than fingers. Female: Trochanter 1.3-1.4 times as long as broad, femur 3.7-3.9 times as long as broad, tibia 2.6-2.9 times as long as broad, chela 3.5-3.8 times as long as broad, hand shorter than fingers (0.9x). Leg I (both sexes): Femur (both subsegments) 3.1-3.3 times as long as deep, basifemur slightly longer than telofemur, telofemur deeper than basifemur, tibia 2.9-3.1 times as long as deep, tarsus (both segments) 4.2-4.6 times as long as broad. Leg IV (both sexes): Femur (greatest length of both subsegments) 3.4-4.0 times as long as deep, tibia 3.8-4.3 times as long as deep, tarsus (both segments) 4.7-5.0 times as long as deep.

Basitarsus of all legs subequal in length to telotarsus.

*Measurements* (in mm.).—Male (holotype). Total length (KOH cleared) 2.22, abdominal breadth 1.25. Carapace 0.67 long, 0.82 broad posteriorly, and 0.44 wide behind eyes. Cucullus 0.197 long. Palps: Trochanter 0.339 by 0.251, femur 0.818 by 0.197, tibia 0.654 by 0.215, chela 1.191 by 0.272, hand 0.572 long and 0.251 deep, fingers 0.625 long. Leg I: Femur (both subsegments) 0.390 by 0.116, basifemur subequal to or slightly longer than telofemur, tibia 0.239 by 0.084, tarsus (both segments measured as a miotarsus) 0.284 by 0.064. Leg IV: Femur (greatest length of both subsegments) 0.574 by 0.143, tibia 0.366 by 0.095, tarsus (both segments measured as a miotarsus) 0.349 by 0.071.

Female (allotype). Total length (KOH cleared) 2.74, abdominal breadth, 1.6. Carapace 0.82 long, 1.00 broad posteriorly, and 0.52 broad behind eyes. Cucullus 0.230 long. Palps: Trochanter 0.425 by 0.320, femur 0.984 by 0.251, tibia 0.780 by 0.277, chela 1.424 by 0.379, hand 0.689 long and 0.343 deep, fingers 0.754 long. Leg I: Femur (both subsegments) 0.494 by 0.151, basifemur slightly longer than telofemur, telofemur deeper than basifemur, tibia 0.301 by 0.100, tarsus (both segments) 0.335 by 0.074. Leg IV: Femur (greatest length of both subsegments) 0.762 by 0.194, tibia 0.495 by 0.115, tarsus (both segments) 0.425 by 0.084.

Of four specimens measured, the following extremes in total length and palpal dimensions were found (male and female): Trochanter 0.339-0.425 by 0.251-0.320, femur 0.807-0.984 by 0.197-0.251, tibia 0.654-0.780 by 0.215-0.280, chela 1.166-1.424 by 0.272-0.384, hand 0.572-0.689 long, fingers 0.625-0.754 long. Total body length 2.22-2.80.

*Remarks.*—See discussion under *Synsphyronus* (*S.*) *mimetus*, sp. nov. (p. 496). The length of the basitarsus of the legs is subequal to that of the telotarsus.

***Synsphyronus* (*Maorigarypus*) *melanochelatus* (Chamberlin)**

Figure 21

1930. *Maorigarypus melanochelatus* Chamberlin, Ann. and Mag. Nat. Hist. (10), 5: 617.  
 1931. *M. melanochelatus* Chamberlin, Chamberlin, Stanford Univ. Pubs., Univ. Ser., Biol. Sci., 7 (1): 141, fig. 37, *S* (chela); 160, fig. 42, *H* (arolium); 164, fig. 44, *E* (leg I).  
 1932. *M. melanochelatus* Chamberlin, Beier, Das Tierreich, 57: 226.

*Diagnosis* (addenda).—Chaetotaxy of chela as illustrated (fig. 21); setae ST, SB, and B absent; accessory seta A present. Movable finger of chela with 41, fixed finger with 53, marginal teeth. The following palpal proportions are from the holotype and allotype, respectively (male first, then female): Trochanter 1.33–1.37 times as long as broad, femur slightly longer than carapace and much longer than tibia, 4.07–4.26 times as long as broad, tibia 2.63–2.79 times as long as broad, chela 3.42–3.38 times as long as broad, hand 1.56–1.58 times as long as broad. Fingers distinctly longer than hand (1.19–1.14 times).

*Measurements* (in mm.).—Male (holotype). Total length (KOH cleared) 3.36, abdominal breadth indet. Carapace 1.01 long and 1.14 broad posteriorly. Cucullus 0.252 long. Palps: Trochanter 0.494 by 0.373, femur 1.120 by 0.275, tibia 0.858 by 0.327, chela 1.651 by 0.485 (0.448 deep), hand 0.756 long, fingers 0.896 long.

Female (allotype). Total length (KOH cleared) 4.01, abdominal breadth 2.05. Carapace 1.04 long by 1.26 broad posteriorly. Cucullus 0.261 long. Palps: Trochanter 0.513 by 0.373, femur 1.232 by 0.289, tibia 0.886 by 0.317, chela 1.732 by 0.513, hand 0.812 long; fingers 0.924 long.

*Remarks.*—Known only from the type collection from Ohakune, New Zealand. Types in the British Museum.

The homologies of the tactile seta of the chela as given by Chamberlin in 1931 (*op. cit.*, fig. 37S) are now believed to have been in error. The present interpretation of these homologies is shown in fig. 21.

***Synsphyronus* (*Maorigarypus*) *viridis* (Tubb)**

1937. *Maorigarypus viridis* Tubb, Roy. Soc. Victoria Proc. (n. s.) 49: 412–413, tf. 1a (palp), 1b (tergal seta), and 1c (palpal seta).

*Remarks.*—Tubb does not give palpal measurements or detailed proportions. Neither does he figure or describe in detail the chaetotaxy and dentition of the chela. This makes it difficult to give a critical evaluation of his species which, however, seems sufficiently distinct.

Assuming that his illustration of the palp is accurate, the following approximate palpal proportions have been computed: Femur 4.0 times as long as broad, tibia 2.5 times as long as broad, chela 3.3 times as

long as broad. Tubb states that the tibia is 2.2 times as long as broad, but, unless his figure is in serious error, the true proportion on the basis of the key points employed in my studies is closer to 2.5 times, as indicated above. The discrepancy may be due to the employment of different key points in measuring the tibial length. The general appearance of the palps, as shown by Tubb's illustration, is typical of the genus.

The green coloration noted by Tubb and upon which the specific name is based cannot be properly evaluated as a taxonomic criterion until we know for certain whether it is really specific in nature and, if so, whether it is retained after preservation. In no specimens of the genus seen by me has any "distinctive" coloration been noted, but this does not indicate its absence in living or fresh material.

The tergal chaetotaxy as given by Tubb (four border setae each on segments 1-7 and eight each on segments 8-10), while distinctive, rather closely resembles that of *Synsphyronus* (*Maorigarypus*) *mimulus*, sp. nov.

The species was described from a single female taken under a stone near "Seal Bay, on Lady Julia Percy Island," Australia. The type is presumably deposited in the National Museum at Melbourne.

### **Idiogarypus** gen. nov.

*Orthotype*.—*Garypus hansenii* With.

*Occurrence*.—Only the orthotype, from Tasmania, is known at present.

*Diagnosis*.—Garypine genus of typical facies most closely related to *Synsphyronus*. Carapace of usual form, posteriorly broader than long and lacking transverse furrows; eyes unusually reduced in size and, while situated well distad of median, about eight ocular diameters from anterior margin. Vestitural setae short and clavate; tergites with a marginal series of about six clavate setae on anterior segments; tergites 2 to 10 divided by a narrow stripe; tergite 1 entire, 11 partly divided. Basifemur of legs 1 and 2 subequal to, or slightly longer than, telofemur and with the interfemoral articulation semi-mobile only as in *Synsphyronus*. Tarsus with metatarsus and telotarsus distinct. Chaetotaxy of chela reduced, fixed finger with seven, movable finger with three, tactile setae. Exact chaetotaxal pattern unknown but setae IT, ISB, and IB distributed as in *Synsphyronus*.

Flagellum of three blades, of which the two posterior ones are much reduced; chaetotaxy of fixed finger of chelicera unknown but galeal seta of movable finger median in position and, if correctly illustrated, much caudad of terminal attachment of serrula exterior. Derm of palps, carapace, tergites, and legs densely reticulate, the reticulations occurring in a hyaline pseudoderm as in *Synsphyronus*.

*Remarks*.—The small eyes (eight ocular diameters from the anterior carapacial margin) and the medially placed galeal seta are unique and will at once distinguish *Idiogarypus* from all other genera in the family.



***Idiogarypus hansenii* (With)**

1908. *Garypus hansenii* With, Vidensk. Meddel. Naturh. Foren. (6) 10: 12; pl. 1, f. 11 (chela); 12 (leg I); 13 (leg IV); 14 and 15 (femoral articulation); pl. 2, f. 1 (carapace); 2 (coxal and genital area); 3 (palp); and tf. 2 (flagellum and movable finger chelicera).  
 1930. *Garypus hansenii* With, Chamberlin, Ann. and Mag. Nat. Hist. (10) 5: 612. (Note on possible generic position.)  
 1932. *Maorigarypus hansenii* (With), Beier, Das Tierreich, 57: 226.

*Remarks.*—With's description of the chaetotaxy of the chela is incomplete but sufficient to indicate that it is very probably much the same as in *Synsphyronus* except for the absence of one of the exteriorly placed setae (probably ISB). He reports only seven setae on the fixed finger, three interiorly (as in *Synsphyronus*) and four exteriorly, these latter "arranged in a long row from base to near tip."

For convenience of reference, With's measurements (in mm.) of this species are reproduced herewith.

Length (male type) 3.59, abdominal breadth 1.87. Carapace ("cephalothorax") 0.99 long, 1.078 broad posteriorly, "anterior" breadth 0.242. Palps: Trochanter 0.420 by 0.380, femur 1.144 by 0.286, tibia 0.858 by 0.330, hand 0.782 by 0.420 (0.352 deep), fingers 0.924 long. Chela not measured by With, but on the basis of his figure it should be 1.73–1.75 long. Leg I: Basifemur 0.299 by 0.161, telofemur 0.261 by 0.175, tibia 0.356 by 0.120, basitarsus 0.204 by 0.088, telotarsus 0.168 by 0.074, tarsus (both segments), about 0.37 by 0.088. Leg. IV: Femur (both segments) 0.760 by 0.204, tibia 0.584 by 0.139, basitarsus 0.234 by 0.102, telotarsus 0.204 by 0.094, tarsus (both segments) about 0.44 by 0.102.

*Remarks.*—The species has thus far been recorded only from Tasmania. The unique type is in the British Museum.

ON YOUR OWN, by SAMUEL A. GRAHAM and EARL C. O'ROKE. Pages 150, 52 figs., 5¼ x 8 in., linen bound. 1943. Published by UNIVERSITY OF MINNESOTA PRESS, Minneapolis, Minn. Price \$2.00.

The subtitle reads: "How To Take Care of Yourself in Wild Country, A Manual for Field and Service Men." At once we recommend this little volume to exploring entomologists. Few men know camping and the woods more intelligently than do its authors. However, their experience is in timber rather than desert. On vacation in ant and dragonfly country our copy will be taken in the family car.

The fourteen sections cover: 1. How to Meet Physical Extremes; 2. Minor Injuries; 3. Quicksand and Water Hazards; 4. Food in the Field; 5. Wild Edible Plants; 6. Wild Animals You Can Catch (and Animals You Should Avoid Eating); 7. Poisonous Plants; 8. Annoying or Dangerous Animals; 9. Insects and Other Irritating Pests; 10. How to Avoid Animal Diseases (Anthrax, Tularemia, Rabies, Spotted Fever, etc.); 11. Disease Carriers; 12. Parasites That Attack Man; 13. Equipment; 14. Do's to Remember; Don'ts to Remember.

On Your Own is, as it should be, a vivid book. The reader after visualizing the uncertainties of life outside of a well managed hospital wonders what he may run into in his yard and Victory Garden; and then the unguarded hours of sleep, a crack in the screen or a crevice under the window ledge.

On Your Own is a he-man's pioneering guide.—C. H. K.

# NEW GENERA AND SPECIES OF ASTEIIDAE (DIPTERA), WITH A REVIEW OF THE FAMILY IN THE AMERICAS<sup>1</sup>

CURTIS W. SABROSKY,<sup>2</sup>

Michigan State College,  
East Lansing, Michigan

Since the publication of a new western species of *Asteia* (Sabrosky, 1939, Pan-Pacific Ent., 15 : 165-167), a few additional specimens of the family have been found in material received for determination. As a result of the study of their proper status, the number of new points uncovered appeared to justify a summation of the family as a whole for the western hemisphere. Two genera and six species are described as new, one old generic name was found to be preoccupied, and one Palaearctic genus is recorded from North America for the first time. Because of the number of new combinations, a check list of the family for North and South America has been prepared according to the generic arrangement adopted here.

## KEY TO THE GENERA OF ASTEIIDAE OF THE AMERICAS

1. Posterior crossvein absent; alula lacking.....2  
Posterior crossvein present.....4
2. Two pairs of dorsocentral bristles; first and second veins not ending together in the costa, leaving a short second costal sector (i. e., the section of costa between the tips of the first and second longitudinal veins)..... **Asteia**  
One or three pairs of dorsocentral bristles; first and second veins ending together in the costa, thereby eliminating the second costal sector (fig. 1)....3
3. One pair of very long dorsocentral bristles, as long as the apical scutellars; no strong fronto-orbital bristle developed, though one weak upper orbital is slightly longer than the others; third antennal segment peculiarly bifurcate, with an irregularly serrate margin and numerous unusually long hairs (fig. 2)..... **Loewimyia**  
Three pairs of dorsocentral bristles, the foremost pair anterior to the mesonotal suture; one pair of long, recurved fronto-orbital bristles, situated midway between the level of the median ocellus and the anterior margin of the front; third antennal segment not bifurcate and with margin entire,..... **Asteimyia**
4. Second longitudinal vein long, ending distad the middle of the wing; second costal sector decidedly longer than the first sector.....5  
Second vein very short, abruptly recurved so as to end in the costa at or only slightly beyond the end of the first vein; second costal sector at most only one-third the length of the first sector.....6
5. Arista bare or slightly pubescent; anterior crossvein proximad the junction of first vein with costa..... **Lelomyza**  
Arista with a number of long rays; anterior crossvein distinctly distad the junction of first vein with costa..... **Stenomicro**

<sup>1</sup>Journal Article No. 556 (n. s.) from the Michigan Agricultural Experiment Station.

<sup>2</sup>The writer wishes to express his appreciation to Mr. C. T. Greene of the U. S. National Museum and Mr. Nathan Banks of the Museum of Comparative Zoology for rechecking the types of Asteiidae at their respective institutions, and to Miss Elizabeth B. Bryant of the Museum of Comparative Zoology for examining the original publication and other literature for the exact use of *Sigaloessa* in the Arachnida.

6. First and second longitudinal veins end together in the costa, eliminating the second costal sector; alula absent or nearly so, with few hairs; two pairs of dorsocentral bristles; discal cell short, the ultimate section of the fifth vein longer than the penultimate section of the fourth vein. . . . **Crepidohamma**  
Second vein ends in costa distad the first vein, leaving a short but distinct second costal sector (figs. 4, 5); a small alula present, with a fringe of long hairs. . . . 7
7. One pair of dorsocentral bristles; third and fourth veins strongly converging, their apices less than the length of the hind crossvein apart; discal cell long and narrow, the fore crossvein adjoining it far before the middle, at the basal third of the cell; ultimate section of fifth vein shorter than the penultimate section of fourth vein (fig. 4). . . . **Phlebosotera**  
Two pairs of dorsocentrals; third and fourth veins not as close together at their apices, separated by the length of the hind crossvein or slightly more; discal cell shorter, though not as short as *Crepidohamma*, the fore crossvein at or slightly before the middle of the cell; ultimate section of fifth vein generally subequal the penultimate section of fourth vein (fig. 5). . **Astiosoma**

### Genus *Stenomicro* Coquillett

The genus *Stenomicro* Coquillett has been referred to the Asteiidae by Hendel, and Malloch agreed that it was as close to that family as to the Drosophilidae, though with some resemblance to certain Anthomyzidae. The "families" of the Acalyptrate Diptera are separated on some seemingly slight differences and there is often disagreement on the location of intermediate genera. For my part, *Stenomicro* appears to be close to the Drosophilidae, but available material is not adequate for a detailed study at this time.

### Genus *Asteia* Meigen

#### KEY TO THE AMERICAN SPECIES OF ASTEIA

1. Mesonotum yellow, marked with five pairs of black to reddish black spots which really represent four indistinct stripes and two supra-alar vittulae (western North America). . . . **multipunctata**  
Mesonotum glossy black. . . . 2
2. Mesopleura with a black stripe along the upper margin, connecting with the dark metanotum (Peru). . . . **striatifrons**  
Upper portion of the mesopleura yellow. . . . 3
3. Mesopleura entirely yellow; front brown posteriorly, becoming yellow on the anterior part (eastern U. S.). . . . **beata**  
Mesopleura and pteropleura with a broad black stripe along the lower margin; front shining black up to the anterior edge (Peru, Costa Rica). . . **albovaria**

### *Asteia multipunctata* Sabrosky

Two additional localities may be recorded: Manila, Utah, July 17, 1940 (F. Harmston, G. F. Knowlton); and Central, Utah, May 11, 1939 (Knowlton) (Utah Agr. Exper. Sta. Colln.).

### *Asteia albovaria* Aldrich

The species was described from a single male from Peru, and has not since been recorded, to the writer's knowledge. The only other described Neotropical species of *Asteia* is *A. striatifrons* Malloch, which was also described from one male from Peru, and which is distinguished chiefly by the characters noted in the key.

One female, San Jose, Costa Rica, July (H. Schmidt) (U. S. Nat. Mus.), agrees almost exactly with the description of *albovaria*, notably in such features as the distinctive four-banded appearance of the face. The specimen should perhaps be labeled lectoallotype, but the writer is reluctant to give it such official status on the sole basis of a single specimen from a region quite far removed from the type locality, however probable it may be. The following notes on the thorax of the present specimen are in part an addition to those given by Aldrich, who was unable to ascertain certain features on the holotype.

*Female*.—Mesonotum shining black up to the lower rim of the notopleura and including the humeri. Pleura whitish-yellow, a black stripe extending along the lower margins of the mesopleura and pteropleura, a large subtriangular black spot on the sternopleura and a small dull spot on the hypopleura. Bristles black and strongly developed: 2 pairs of long dorsocentrals (nearly equalling the apical scutellars in length), 1+1 notopleurals, and 1 postalar. In addition to the long, widely separated, erect, apical scutellar bristles, mentioned by Aldrich, there is one pair of weak, pale subapical bristles, scarcely distinguishable on the yellow scutellum, and little longer than the clothing hairs on the mesonotum. One long sternopleural bristle evident, but it is yellow and not prominent. Metanotum shining pitch black. Halteres with yellow stalk and knob with at least a large black spot on the outer surface, or perhaps even more extensively infuscated. Length of body, 1.75 mm.; of wing, 2.25 mm.

### Loewimyia, new genus

Genotype: *Loewimyia bifurcata* Sabrosky, new species.

*Generic diagnosis*.—Genus near *Asteia* Meigen, lacking the hind cross-vein and the alula. Chaetotaxy: long inner and outer verticals, postverticals present but minute, one pair of weakly developed upper fronto-orbitals, scarcely longer than the other hairs; one pair of very long dorsocentral bristles, equal in length to the long erect apical scutellars; two long sternopleurals. Head large, broader than the thorax, the cheeks linear, oral opening small, face narrowed below, eyes separated at the level of the clypeus by half the width of the front at the vertex. Antennae densely clothed with long hairs, the third segment peculiarly bifurcate and with an irregularly serrate margin (fig. 2).

Wing (fig. 1) similar to *Asteia* but for the common junction of the first and second longitudinal veins in costa, and the strong divergence of the fifth vein from the fourth, beginning proximad the anterior crossvein. Abdominal tergites apparently complete, the segmentation distinct.

No evidence of an arista could be found, though all antennae appeared to be intact on the two specimens available. What at first sight seemed to be a short arista proved to be a long, proclinate bristle on the second antennal segment. If further specimens should prove that this form actually lacks an arista, that would be a particularly important generic character.

***Loewimyia bifurcata*, new species**

Figures 1 and 2

Minute dark-bodied species whose most striking characteristics are the bifurcate antennae and the banded legs.

Head large, wider than the thorax, brown to blackish, only the small face, cheeks, palpi and proboscis yellow. Because of the slightly collapsed head, it is dangerous to state proportion too definitely, but the occiput appears to be strongly concave and the front short. Eyes very large, in profile occupying the entire head, approaching each other so as to narrow the face below, and therefore somewhat emarginate along their anterior margin to allow for the insertion of the antennae. Cephalic bristles and hairs black, only the verticals outstanding. Antennae large, porrect, entirely brown black, densely clothed with unusually long hairs, the third segment deeply notched on its anterior surface, the margin irregularly serrate.

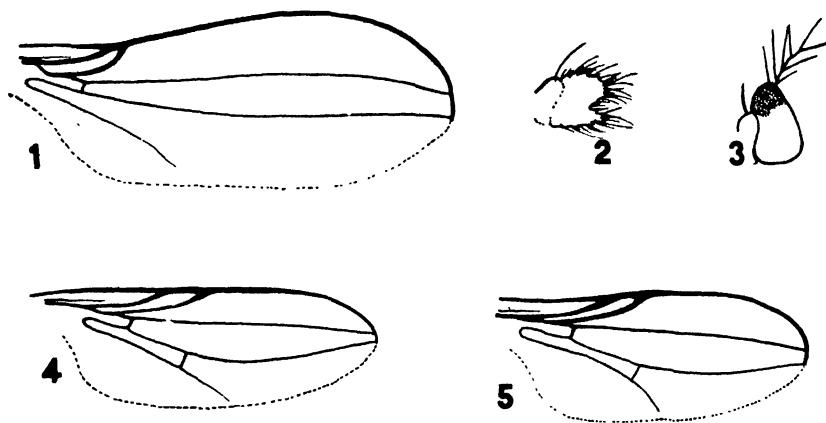


Figure 1, *Loewimyia bifurcata* Sabrosky, wing. 2, *L. bifurcata*, antenna. 3, *Asteimyia antennata* Sabrosky, antenna. 4, *Phlebosolera setipalpis* Sabrosky, wing. 5, *Astiosoma hirta* (Aldrich), wing.

Thorax and abdomen entirely dark brownish black, the margins of the pleural sclerites paler, the whole covered with fine dark pollen. Bristles black, very long and conspicuous on such a tiny insect.

Wing broader than in most Asteiidae in proportion to its length, the submarginal cell very broad, one and one-half times the greatest width of the first posterior cell, the latter narrower than in most species because the third and fourth veins are not so strongly diverging. Fifth vein strongly divergent from the fourth clear back to the base, whereas in *Asteia* and *Asteimyia* the fourth and fifth veins are parallel for some distance beyond the anterior cross vein. Halteres black, the stalk paler basally.

Legs short and weak, bright yellow, with conspicuous black bands at the base and towards the apex of the mid and hind femora, and narrow bands towards the base of the tibiae opposite the apical

femoral bands. The fore legs have a suggestion of the same pattern, but their condition in both specimens is too poor to state it positively. Length of body, .6 mm.; of wing, .8 mm.

Holotype and one paratype, Sabanas, Panama, April 20, 1923 (R. C. Shannon). Sex indeterminable. Types deposited in U. S. National Museum.

### **Asteimya new genus**

Genotype: *Asteimya spinosa* Sabrosky, new species.

**Generic diagnosis.**—Genus near *Asteia* Meigen, lacking the hind crossvein and the alula. Chaetotaxy: long head bristles, 1 inner and 1 outer vertical, and one erect, recurved fronto-orbital, the latter far forward on the front, midway between the median ocellus and the base of the antennae; vibrissae long and porrect; postvertical and ocellar bristles either minute or absent, not discernible in any specimens; 3 pairs of dorsocentrals (one anterior to the mesonotal suture), 1+1 notopleurals, and the anterior intra-alar bristle distinctly developed, about half the length of the dorsocentrals; 1 sternopleural. Head somewhat elongate, the long axis of the eye nearly horizontal, face much broader than its height. Scutellum like *Asteia*, with very long, erect, apical scutellar bristles. Wing similar to *Asteia*, but the first and second veins ending together in the costa. Abdomen largely membranous, judging from the collapsed appearance.

The presence of a strong fronto-orbital bristle so far forward on the front is quite unusual in the family, and the possession of three pairs of dorsocentral bristles has hitherto been known only in *Asteia sexsetosa* Duda from Formosa.

### **KEY TO THE SPECIES OF ASTEIMYA**

1. Bristles of the head and thorax black and conspicuous; third antennal segment rounded, as long as broad; two black crossbands below the antennae, **spinosa**
- Bristles of the head and thorax bright yellow and hence not as conspicuous; third antennal segment pear-shaped or subreniform; only one black crossband below the antennae. . . . . **antennata**

### **Asteimya spinosa new species**

**Male.**—Front yellow to brown, the orbits paler, the central portion and the eyes sunken so that their proportion cannot be determined. Occiput concave, brown. Face and cheeks bright, whitish yellow, the former strikingly marked with two black-brown, parallel crossbands, the one between the widely separated vibrissae across the anterior oral margin, and the other connecting the eyes midway between the oral margin and the base of the antennae. Proboscis and palpi pale yellow. Antennae orange, the third segment brown above, arista black with several long rays toward the base; second antennal segment with a long, erect, diverging black bristle, adding further to the spinose appearance. Cephalic bristles black and strong, the fronto-orbitals as long or longer than the outer verticals, and nearly as long as the conspicuous dorsocentrals.

Thorax entirely bright whitish-yellow below the notopleural ridge, and brown above, including the humeri and metanotum, the two areas sharply demarcated. The brown mesonotum is marked with paler yellowish-brown areas which divide it into six brown stripes, of which the median pair extend back over the sides of the scutellum, the whole finely pollinose and slightly dull. Bristles long, black and conspicuous.

Abdomen collapsed, probably chiefly membranous, the apex sclerotized and bright yellow, as are the claspers. Wings clear, veins brown, apex of second vein enlarged, submarginal cell very broad, slightly wider than the greatest width of the first posterior cell; the fifth vein fades out far before the margin of the wing. Halteres with yellow stalk and black knob. Legs weak, entirely pale yellow. Length of body, .9 mm.; of wing, 1.25 mm.

Holotype, male, Higuito, San Mateo, Costa Rica (Pablo Schild). Paratypes, six specimens with same data, topotypic (1 ♂, others in poor condition). Type series in the U. S. National Museum.

### ***Asteimyia antennata*, new species**

#### Figure 3

Close to *A. spinosa*, but the body color paler, bristles bright yellow instead of black, and the antennae peculiarly developed.

*Male*.—Head yellow, only the ocellar spot, the upper fourth of the third antennal segment, the arista, and a band across the face between the bases of the vibrissae, black. Cheeks narrower than in *A. spinosa* and the cephalic bristles are shorter. Antennae porrect, much higher than long, and since the unusual height appears due chiefly to extension on the dorsal side, the antennae project above the front in profile. Third antennal segment sub-reniform to pear-shaped, the anterior margin nearly straight and the lower half larger than the dorsal portion (fig. 3). Arista with six or seven long rays.

Thorax as in *A. spinosa*, sharply demarcated into an upper brownish and a lower whitish yellow portion by a dark brown band along the notopleural ridge, the whole covered with a sparse pale pollen. The disk of the mesonotum paler, though in dark specimens with a suggestion of a pair of median stripes which end approximately opposite the middle pair of dorsocentral bristles, and on each side a longer lateral stripe which extends from the mesal angle of the humerus to the posterior dorsocentral bristle, the posterior slope of the mesonotum and the scutellum entirely yellow. Metanotum yellow above, shining brown below. Bristles long and bright yellow, the notopleurals darker.

Abdomen collapsed, apparently membranous, the apex shining yellow and sclerotized. Wing near *A. spinosa*, the submarginal cell not quite as broad and the apex of the second vein not enlarged. Halteres brown. Legs weak, pale yellow. Length of body, 1.25 mm.; of wing, 1.75 mm.

Holotype, male, Higuito, San Mateo, Costa Rica (Pablo Schild). Paratypes, five specimens, same data, topotypic (apparently 2 ♂, 1 ♀, and 2 ?). Type series in the U. S. National Museum.

Genus *Crepidohamma* Enderlein

(= *Sigaloëssa* Loew, 1865, nec Blackwall, 1864.)

The group of species listed under *Crepidohamma* have long been known under the name of *Sigaloëssa*. In the course of preparing the check list, the writer was astonished to find in Neave's Nomenclator Zoologicus a reference to an earlier use of the name *Sigaloëssa*, cited as "*Sigaloëssa* (Templeton MS) Blackwall 1864, Hist. Spiders, 2, 198.—Arachn." The name was not listed in the Zoological Record for 1864, and apparently has long been overlooked.

Blackwall (1864, History of the Spiders of Great Britain and Ireland, vol. 2, p. 198, and plate 14) described and figured a new species *Theridion auratum*, under which he cited in synonymy "*Sigaloëssa auratum* Templeton MS. History of Irish Arachnida." Blackwall accepted the species as new, using Templeton's suggested name, but he did not accept the latter's proposed genus.

Under Opinion 4, the manuscript names acquired standing in nomenclature when they were published by Blackwall and must be credited to him. The situation is practically identical with that discussed in Opinion 24 of the International Rules, *re Antennarius* Commerson MS, published but not accepted by Lacépède, who mentioned the name in synonymy. It must be concluded therefore that *Sigaloëssa* has nomenclatorial status as of Blackwall 1864, who published it in connection with a duly described species, even though he did not accept it as a genus. It has been recorded in the literature as a synonym of *Theridion* by Petrunkevitch, in the Systema Aranearum (1928, Trans. Conn. Acad., XXIX, p. 246).

*Sigaloëssa* Loew (1865) must therefore be regarded as a homonym. Since *Crepidohamma* Enderlein (1915) is here found to refer to the same group, that name is hereby adopted as the next available name, making it unnecessary to propose a new name.

The status of *Crepidohamma* Enderlein may be questioned by some because of its separate recognition by recent authors (Duda, Curran), though Sturtevant (1921, Carnegie Inst. Publ. No. 301, p. 106) had stated it to be a synonym of *Sigaloëssa* Loew. Curran (1934, Fam. Gen. N. Amer. Diptera, p. 328) in his key distinguished *Crepidohamma* by "Front with two bristles near the middle, half way between the ocellar triangle and antennae" whereas *Sigaloëssa* Loew was said to have "Front with only weak bristles laterally." The latter apparently is true for *S. rica* Curran, but *S. bicolor* Loew, the genotype, has a rather long, strong, fronto-orbital bristle about midway on the front, slightly anterior to the level of the median ocellus. Duda (1927, Deut. Ent. Ztschr., p. 119) did not include *Sigaloëssa* in his key, but characterized *Crepidohamma* in part as follows: "Stirn teilweise matt, nahe der Medianlinie auf der Stirnmitte mit zwei Borsten, danach Oz. anscheinend weit vorn stehend." Duda stated definitely that the species was unknown to him, and his version could only have been based on the published description.

Enderlein's original description of *Crepidohamma brasiliense* reads: "An dem Augenrand je 1 Borste in der Mitte der Stirn, und 2 nahe der Medianlinie in der Mitte der Stirn. An der Seite des Scheitels eine



lange Borste." Duda recognized that the bristles near the mid-line of the front must appear like the ocellars (which are normally proclinate and may superficially appear to arise farther forward than is actually the case). Indeed, Enderlein does not mention the ocellars, nor does he indicate how well developed either these or the orbitals are. If we interpret his description, which is somewhat indefinite on these points, as meaning that the front showed one distinct pair of fronto-orbital bristles and one pair of proclinate ocellars, the entire characterization will match that of *Sigaloëssa* Loew. It is of course possible that *Crepidohamma* is really distinct on this or other characters, but until it can be proved, I prefer to regard them as one and the same and to avoid the creation of a new name for *Sigaloëssa* until the premises for such action are properly established. Fortunately, Enderlein's excellent figure of the wing of *Crepidohamma* and his further notes on the venation leave no doubt of its separation from *Astiosoma* and *Phlebostera*.

It may be noted that most of the species heretofore described as *Sigaloëssa* may be referred to *Astiosoma* Duda. Of those not found in our check list, it appears from the description that *S. insularis* Malloch (1930), from the Society Islands, falls in *Crepidohamma* as here defined.

#### KEY TO THE AMERICAN SPECIES OF CREPIDOHAMMA END.

1. Thorax pale ferruginous to reddish yellow (Puerto Rico).....*rica*  
Mesonotum black.....2
2. Posterior half of the front black (So. Brasil).....*brasiliense*  
Posterior three-fourths of the front black.....3
3. Legs entirely yellow or with a small oval black spot on the outer surface  
near the apex of the fore femora (West Indies and Central America)..*bicolor*  
Legs yellow with conspicuous, black to black-brown bands.....4
4. Thorax entirely brown to pitch black; fore coxae dark brown; tibiae entirely  
yellow (Panama).....*cinctipes*  
Humeri and part of the pleura bright yellow; fore coxae yellow; fore and  
middle tibiae with narrow black basal bands (Costa Rica)....*pseudocinctipes*

#### *Crepidohamma bicolor* (Loew), n. comb.

(= *Sigaloëssa frontalis* Aldrich, 1915, *Psyche*, XXII, p. 98. New synonym.)

Male, Soledad near Cienfuegos, Cuba, Aug. 6-20 (N. Banks), and male, five females, Soledad, Cuba, Feb. 25, 1925 (George Salt) (Mus. Compar. Zool., Harvard); five males, one female, Higuito, San Mateo, Costa Rica (Pablo Schild); male, two females, San Jose, Costa Rica, "V : 15 : VII" (H. Schmidt); female, Sabanas, Panama, April 20, 1923 (R. C. Shannon); male, Monte Liro, Canal Zone, Aug. 28, 1923 (R. C. Shannon); female (?), Ancon, Canal Zone, Oct. 8, 1923 ("Ex pods of *Moringa oleifera*"); one, Corazal, Canal Zone, March 1, 1912 (August Busck); one, Trinidad Rio, Panama, March 16, 1912 (August Busck). (U. S. National Museum.).

Loew described the species from the female sex as having entirely yellow legs. The small series from Cuba indicated that the males had an oval dark brown to black spot on the distal fourth of the posterior surface of the fore femora, but the distinction did not seem to hold true in the series from Central America. Perhaps this was due to the condition of the specimens, since the abdomens are so collapsed that one cannot always be sure of the sex, or perhaps another almost identical form is

intermingled. At any rate, the latter series cannot be distinguished from what is regarded as typical *bicolor* from Cuba.

Two aberrations in chaetotaxy were noted, both of which suggest that those characters be used with caution unless supported by other evidence. The specimen from Sabanas, Panama, possessed two well-developed fronto-orbital bristles on the left side and only one on the right. In the Ancon example, there were two bristles inserted very close together at the position of the left anterior dorsocentral, but only the normal single anterior dorsocentral on the right, resulting in the appearance of a row of three bristles on the left side and two on the right.

### ***Crepidohamma cinctipes*, new species**

A shining black species, marked with yellow.

*Female*.—Head black to black-brown, including the narrow, shining black horseshoe-shaped oral margin, which is strikingly distinct beside the silvery white cheeks and yellow face; a narrow anterior frontal margin and the antennae deep yellow to orange, the latter browned dorsally. Clypeus and palpi brown, the proboscis yellow. Front subquadrate, the one pair of moderately developed fronto-orbital bristles slightly anterior to a line drawn through the median ocellus. Ocellars and postverticals short and inconspicuous. Cheeks narrow. Antennae pendant, the third segment ovate, arista long, moderately zig-zag with a number of short rays, apparently about eight on each side.

Thorax shining pitch black, though covered with a sparse, fine pollen which scarcely interrupts the shine, only the scutellum bright yellow, the humeri, notopleura, and margins of some of the pleural sclerites pale brown. The two pairs of dorsocentral bristles and two sternopleurals long and dark brown, the long apical scutellars pale brown.

Abdomen chiefly membranous, the sclerotized tergal areas confined to a short plate at the base adjacent to the metanotum and a complete band around the apex, between which is a row on the median line of three short, narrow tergites, whose width is little more than the space separating the apical scutellar bristles; sclerotized areas dark brown.

Wings essentially like the figure of the wing of *Sigaloëssa rica* in Curran (1934, op. cit., p. 328, fig. 1), the discal cell a little longer and narrower, and the third and fourth veins not as close together at their apices. Halteres with black knob and yellow stalk.

Legs bright yellow, the fore coxae, apical three-fifths of the fore femora, and broad bands near the apices of the mid and hind femora, black to pitch black.

Length of body, 1.4 mm.; of wing, 1.75 mm:

Holotype, female, Cano Saddle, Gatun Lake, Panama, May, 1923 (R. C. Shannon). Type in the U. S. National Museum.

The specimen is brightly colored and in excellent condition, and appears as if mounted out of alcohol or other preservative. The abdomen is thus well preserved and fully distended. From it one can understand why in specimens of certain genera (e. g., *Crepidohamma* and *Asteimyia*) the abdomen is so often a dark shapeless mass, because of the predom-

inantly membranous condition. Other genera observed (*Loewimyia*, *Astiosoma* spp.) have the tergites complete. This character may well be of generic importance, but because of the frequently poor condition of the specimens one cannot always apply it with certainty.

***Crepidohamma pseudocinctipes* new species**

Similar to *C. cinctipes*, differing slightly in coloration of legs and pleura.

*Female*.—Front considerably longer than broad. Arista long, with about ten short rays on each side. Humeri, upper posterior third of the mesopleura, the upper part of the pteropleura, and at least the upper part of the sternopleura, bright yellow. Fore coxae bright yellow, in some specimens with a brown streak; the apical black bands on all femora narrower than in *C. cinctipes* and apparently the fore and hind tibiae typically with narrow black bands towards the base, directly opposite the femoral bands. Length of body, 1.25 mm.; of wing, 1.5 mm. Otherwise as described for *C. cinctipes*.

Holotype, female, Higuito, San Mateo, Costa Rica (Pablo Schild). Paratypes, seven specimens (1 ♂, 1 ♀, 5 ?), same data. Type series in the U. S. National Museum.

The two new species of *Crepidohamma* described above are very similar, and the writer was at first inclined to group them all as one species. However, the complete absence of bands of infuscation on the tibiae of the well preserved Panama specimen, and their presence on the Costa Rican material in comparatively poor condition, leads one to suspect that the character may be a characteristic difference in the two populations. Slight differences in other features also suggest the expediency of recognizing the two forms at this time, though further material might indicate that they were only subspecies or perhaps varieties of the same species. In some specimens of *pseudocinctipes*, the tibial bands are very faint, but this is apparently due to their poor condition.

**Genus *Phlebosotera* Duda**

*Phlebosotera* is here recorded from North America for the first time. Duda's proposal of this and the following genus (*Astiosoma*) was adopted only after a careful analysis of the characters of the several genotypic species and their relatives, including the American species described under *Sigaloëssa* Loew (cf. *Crepidohamma*).

It appears to the writer that Duda's genera may be maintained as separate entities with the characters indicated in the key. Three species referable to *Phlebosotera* are available—from Utah, Southwest Africa, and Palestine—and all agree closely in all structural characters, and indeed can only with great difficulty be separated from one another specifically. *Astiosoma* is closer to *Sigaloëssa* Loew than is *Phlebosotera*, and the latter has much more claim to recognition.

Another character which may be significant in establishing *Phlebosotera* as a valid genus is the presence of distinct folds or ridges marking the position of the sixth longitudinal vein and a truncate anal cell. One might infer from Duda's (1927) key that the veins bounding the anal

cell are actually present, but as Hendel has already noted (Bull. Soc. Roy. Ent. Egypte, 1931, p. 65), they are not definite veins but merely folds. For that reason Hendel doubted their importance as generic criteria. However, this appearance (as figured by Duda, 1927, pl. 5, fig. 5) is present in all three species of *Phlebosotera* now before me, whereas in all species of *Sigaloëssa* and *Astiosoma* known to me the sixth vein is not developed and the anal cell is not truncate and is only weakly indicated as a narrow oval area at the base of the discal cell (cf. Duda, 1927, pl. 5, fig. 6, wing of *Astiosoma rufifrons*).

***Phlebosotera setipalpis*, new species**

Figure 4

Bright yellow species with reddish mesonotum, darkened so as to appear striped; palpi with long porrect terminal bristles.

*Male*.—Head entirely yellow, only the arista and a spot between the ocelli black; the face, cheeks and clypeus nearly white; the front, occiput centrally, and antennae deep yellow, the genoverical plates slightly darker. Front barely wider than an eye, the sides slightly convergent anteriorly. Occiput concave. Eyes bare. Cheeks narrower than the breadth of the third antennal segment, and approximately one-fifth the vertical height of an eye, with a row of 5-6 pale whitish yellow hairs on the lower margin and a pale but distinct vibrissal hair. Third antennal segment ovate, arista slender and apparently bare, but with minute pubescence under high magnification. Palpi long and slender, each bearing a pale yellow terminal bristle fully as long as the palp itself and in the specimen at hand these bristles are porrect, outwardly curved, and cruciate, appearing from above as diverging bristles projecting from the oral margin. Frontal bristles and hairs yellow to brown; the inner and outer vertical bristles well developed; ocellars minute, proclinate and widely divergent; postverticals indistinguishable from a group of minute postocellar hairs; fronto-orbitals minute, with one pair opposite the median ocellus a trifle longer and darker than the others; frontal hairs generally sparse, but numerous just above the antennae.

Thorax and scutellum with whitish yellow ground color, the mesonotum up to the notopleura and humeri deep yellow to reddish, laterally pitch brown to black and appearing as a stripe on each side extending from the neck mesad of the humerus and back to the postalar bristle as a narrow supra-alar vittula. Between these infuscated margins, the mesonotum is slightly darkened as four vittae, the two outer (whose lateral margins are also infuscated) ending at the dorsocentral bristles, and the mesal two somewhat abbreviated. Entire thorax subshining, but thinly bright yellow pollinose. Pleura with brown to reddish brown spots as follows: two small spots beneath each humerus, an elongate oval spot along the lower margin of the mesopleura, a large subtriangular spot on the sternopleura (chiefly reddish, but infuscated on the upper third), and a spot on the hypopleura. Metanotum large and black, subshining but chiefly covered with sparse pale pollen. Bristles long, yellow to brown: 1 anterior notopleural (posterior broken?), 1 postalar, 1 posterior dorsocentral,

1 apical and 1 subapical scutellar, and 1 sternopleural. Mesonotal hairs short and pale, arranged in eight regular rows, with two rows of acrostichals. Mesopleura hairy.

Abdomen in poor condition, but seems predominantly yellow; male genitalia large and knob-like, deep yellow, shining, thickly beset with short, erect hairs. Wings (fig. 4) hyaline, veins yellow, the venation identical with that figured by Duda (1927, pl. 5, fig. 5) for the genotype, *P. mollis*. Halteres yellow. Legs slender, entirely yellow, only the claws black. Length, 2 mm.

Holotype, male, Delta, Utah, July 5, 1938 (G. S. Stains). To be returned to the Utah Agricultural Experiment Station Collection, for ultimate deposit in the U. S. National Museum.

It is possible that the unusually long bristles on the palpi are characteristic only of the male sex, as noted for certain *Hippelates* (Chloropidae). However, they are not found in an available male of the genotype, *Phlebotoma mollis* Duda, and may be regarded as a specific character.

### Genus *Astiosoma* Duda

Acceptance of this generic concept involved relocation of the species originally described under *Sigaloëssa* Loew. As shown by the check list, the Neotropical species are retained in the latter group (under the name *Crepidohamma* to replace *Sigaloëssa* Loew, preoccupied); the Nearctic species are referred to *Astiosoma*. Malloch (1930, Ann. Mag. Nat. Hist., ser. 10, VI, pp. 321, 322) had already noted that *Sigaloëssa flaveola* Coquillett belonged there, as well as his *S. melbournensis* from Australia.

The key to "*Sigaloëssa*" given by Aldrich (1915, op. cit., p. 96) covers the species referred to *Astiosoma*, along with *bicolor* Loew. However, it cannot be used for the species because through some error, *hirta* Aldrich is keyed as having "mesopleura without stripe" whereas the description definitely states that the mesopleura does have a stripe on the lower part.

#### KEY TO THE AMERICAN SPECIES OF ASTIOSOMA DUDA

1. Mesonotum reddish-yellow (eastern U. S.)..... *flaveola*  
Mesonotum shining black..... 2
2. Mesopleura with a black stripe just below the notopleural suture (Idaho),  
lineata  
Mesopleura with a black stripe along the lower margin, adjacent to the  
sternopleura (Idaho; N. C.?)..... *hirta*

### *Astiosoma flaveola* (Coq.)

The only locality I can add to published records is Falls Church, Va., October 7 (N. Banks) (Mus. Compar. Zool.).

### *Astiosoma hirta* (Ald.), n. comb.

#### Figure 5

Described from a single female, Potlatch, Idaho. In material received from the U. S. National Museum are four females, Yale, Latah Co., Idaho, July 28, 1927 (J. M. Aldrich). Cf. fig. 5, wing.

**Astiosoma** sp. (*hirta* Ald.?)

One female, Raleigh, N. C., Aug. 22, 1936 (C. S. Brimley) (N. C. Dept. Agr. Colln.) cannot be separated from *A. hirta* Aldrich. The North Carolina specimen has a row of three hairs on the sternopleura compared with four in available specimens of *hirta*, and the front is a trifle narrower, but these differences seem slight. Because of the widely separated localities, one is inclined to doubt the identity, but lack of sufficient material precludes a definite decision. The specimen is recorded here because it is important to note the presence of another species of *Astiosoma* (besides *flaveola*) in eastern United States. It may also be added that this is the first record of the family from North Carolina (cf. Brimley, 1938, Insects of North Carolina).

## CHECK LIST OF THE AMERICAN ASTEIIDAE

- Asteia* Meigen, 1830, Syst. Besch., VI, p. 88.  
*albovaria* Aldrich, 1915, Psyche, XXII, p. 95. (Peru.)  
*beata* Aldrich, 1915, Psyche, XXII, p. 95 (Mass.; oc. Maine to Ill.).  
*multipunctata* Sabrosky, 1939, Pan-Pacific Ent., XV, p. 165. (Brit. Col. to N. Mex.).  
*striatifrons* Malloch, 1930, Ann. Mag. Nat. Hist., (ser. 10), VI, p. 323. (Peru).  
*tenuis* Walker, 1858, Trans. Ent. Soc. (London), V, p. 331. (U. S.). Probably not an Asteiid.
- Asteimyia* Sabrosky, n. gen.  
*antennata* Sabrosky, n. sp.  
*spinosa* Sabrosky, n. sp.
- Astiosoma* Duda, 1927, Deut. Ent. Ztschr., 1927, p. 119, 127.  
*flaveola* Coquillett, 1898, Jour. N. Y. Ent. Soc., VI, p. 49, (*Sigaloëssa*) (N. H. to Fla.; oc. west to Kansas).  
*hirta* Aldrich, 1915, Psyche, XXII, p. 97 (*Sigaloëssa*). (Idaho). N. comb.  
*lineata* Aldrich, 1915, Psyche, XXII, p. 96. (*Sigaloëssa*). (Idaho). N. comb.
- Crepidohamma* Enderlein, 1915, Wien. Ent. Ztg., XXXIV, p. 185. (= *Sigaloëssa* Loew, 1865 (1866?) nec Blackwall 1864).  
*bicolor* Loew, 1865 (1866?) Berl. Ent. Ztschr., IX, p. 186. (*Sigaloëssa*). (Cuba). N. comb.  
*brasiliense* Enderlein, 1915, Wien. Ent. Ztg. XXXIV, p. 186. (Brasil).  
*cinctipes* Sabrosky, n. sp.  
*frontalis* Aldrich, 1915, Psyche, XXII, p. 98. (*Sigaloëssa*). (Peru) = *bicolor* Loew. N. syn.  
*insularis* Curran, 1931, (*Sigaloëssa*). Preoccupied, cf. *rica*. (Puerto Rico).  
*pseudocinctipes* Sabrosky, n. sp.  
*rica* Curran, 1934, Fam. Gen. N. Amer. Dipt., p. 328. (*Sigaloëssa*). N. comb.  
(= *Sigaloëssa insularis* Curran, 1931, Amer. Mus. Novitates No. 456, p. 13, nec *S. insularis* Malloch 1930).

- Leiomyza* Macquart, 1835, Hist. nat. Dipt., II, p. 605. (= *Liomyza* auctt.)  
*melanderi* Aldrich, 1919, Ent. News, XXX, p. 141. (Wash., Ida., Quebec).  
*slossonae* Aldrich, 1919, Ent. News, XXX, p. 140. (Wash., Ida., N. H.).  
*Leiomyza* Agassiz, 1846, et auctt. (emend. pro *Leiomyza* Macquart, 1835).  
*Loewimyia* Sabrosky, n. gen.  
*bifurcata* Sabrosky, n. sp.  
*Phlebosotera* Duda, 1927, Deut. Ent. Ztschr., 1927, pp. 119, 125.  
*setipalpis* Sabrosky, n. sp.  
*Sigaloëssa* Loew, 1865 (1866?), Berl. Ent. Ztschr., IX, p. 186.  
 Preoccupied by *Sigaloëssa* Blackwall, 1864, Hist. Spiders, II, p. 198.  
 Cf. *Crepidohamma* End.  
*dispar* Schiner, 1868, Novara Reise, p. 237, (*Sigaloëssa*). (S. Amer.).  
 Not an Asteiid, from the description.  
*Stenomicro* Coquillett, 1900, Proc. U. S. Nat. Mus., XXII, p. 262.  
*angustata* Coquillett, 1900, Proc. U. S. Nat. Mus., XXII, p. 262. (Puerto Rico).

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THE EARTH AND MAN—A HUMAN GEOGRAPHY, by DARRELL HAUG DAVIS. Pages xiii+675, 7½ x 10¼ inches, 452 figures. Published by THE MACMILLAN COMPANY, New York. 1942. Price, \$4.25.

All biologists will agree to the desirability of a broad background of training in a variety of subjects for work in the field of biology. The biologist needs an appreciation of ecology and interrelationships, and above all, he needs a concept of human ecology in its broadest sense in order to see his own limited field in its proper perspective. Geography, which is essentially a phase of human ecology, is a subject too often neglected by students of biology. The present book is an excellent treatment of ecological human geography.

This book is intended as a text for beginning classes in geography, and is written to supply a background of information and to establish certain principles. The treatment is divided into five parts: Part I (pp. 1-14), Introduction, outlines the historical development of geography and mapping; Part II (pp. 15-102), Man and Environment, discusses the distribution of man, interactions between man and environment, and environmental changes resulting from natural and human agencies; Part III (pp. 103-361), Limiting Effects of Environmental Factors, discusses climate, soils, land forms and drainage, minerals, inland waters, oceans, and space, and the limitations each imposes on the potentialities of an area for effective human use; Part IV (pp. 362-594), How Man Obtains His Living, deals with man's economic activities and their environmental basis (primitive hunting and fishing, grazing, agriculture, forestry, mining, transportation, industry, and urbanization); Part V (pp. 595-664), Appendix, includes discussions and illustrations of map projection, topographic mapping, solar relations and the reckoning of time, weather maps and weather prediction, climate and soil classifications, and contains a number of useful tables.

The book shows evidence of careful preparation and editing. The subject matter is well organized and clearly presented, and the illustrations are excellent. The many maps, charts, and photographs have apparently been carefully selected and captioned to supplement the accompanying text, and the reader can follow the subject through the book merely by studying the illustrations. The type is somewhat smaller than that in most texts, and is set in two 2¾-inch columns to the page.

This book is not only interesting reading, but contains much of value to the biologist. We heartily recommend it to anyone who wants to better understand the relationships between man and his environment.—D. J. B.

# THE NESTING HABITS OF MEXICAN SOCIAL AND SOLITARY WASPS OF THE FAMILY VESPIDAE

PHIL RAU,

Kirkwood, Missouri

A second trip to Mexico during July 1940 yielded some interesting data on the nesting habits of certain social and solitary Hymenoptera of the family Vespidae.<sup>1</sup>

Entering Mexico from McAllen, Texas, our route ran from Reynosa across the desert to Monterey and thence via the International Highway to Mexico City, and down from the central plateau to Acapulco on the Pacific, then back to Mexico City and out on the southeast spur to Orizaba and Cordoba, and by the northeast spur through Jalapa to the city of Vera Cruz on the Gulf of Mexico. The routes to Vera Cruz and Acapulco were not covered in the 1939 trip (see *Ann. Ent. Soc. Amer.* 33: 81, 1940). Collections and observations were made along the highway, and three short side trips were taken: one to Coatepec, eight miles from Jalapa (alt. 4500 ft.), one to Pie de la Cuesta (alt. 6 ft.) near Acapulco, and one to Xilitla (alt. 2000 ft.) near Tamazunchale.

Locality records are easily made all along the highways of Mexico because each kilometer is marked designating the distance from the national capital. One needs only to record the nearest kilometer number and later consult his map for the exact geographical location. Abandoned buildings, the favorite nesting site of many wasps, are few along the highway, since practically everything is utilized by the natives as a habitation. One must therefore resort to scanning the vegetation and the underside of bridges and culverts on the road for likely material. The bridges and culverts under the older roads in the tropical regions of low altitude are often rich in insect life; those recently constructed are only beginning to acquire their insect fauna. In this respect I noticed that there was a marked difference in the fruitfulness of certain new culverts in the two trips, only sixteen months apart.

These culverts and bridges were soon found to be a fair index of the region's entomological resources. For example, along the old road in the arid region from Reynosa to Monterey for a distance of 140 miles, a hundred culverts were searched in vain. In contrast to this dearth of life in the high desert region the insect fauna became abundant in culverts as soon as we entered low tropical regions. It is of course conceded that culverts, bridges, and roadsides do not tell the story of the insect fauna in the hinterland, yet in general it is an indicator which helps the naturalist to decide whether or not to penetrate further into the wilderness.

The heavy task of identifying all of the Vespidae discussed here was generously undertaken by Dr. Joseph Bequaert, to whom I wish to

<sup>1</sup>Other papers in course of preparation from data collected on this trip are on certain solitary wasps (Sphecidae), on social and solitary bees, and on the behavior of certain butterflies.



express my very deep appreciation. I also wish to express my thanks to the entomologists who identified insects other than wasps, and whose names appear in brackets after the species name.

## POLYBIA WASPS

### *Metapolybia cingulata* Fabr.

The nest of this wasp is a single comb which is attached to a horizontal support or beam. It is unique in that the wasps cover this comb with a layer of brown paper beautifully studded with transparent windows. This covering is rather loosely spread beneath the comb, leaving an air space as well as walking room for the colony of adults. The sheet of papery covering looks very much like the bark of trees, and for another nearly related species, *M. pediculata* in Panama, Dr. Bequaert states that they "usually build nests against trees, the outer envelope then imitating perfectly the bark, and is often speckled with algae, lichens, etc." (Jungle Bees and Wasps of Barro Colorado Island, p. 52, 1933). The covering of *M. cingulata* also resembles bark, and I often wonder how many of these nests I failed to see in the woods because of this close resemblance.

Only two nests of this species were seen; one at Tierra Colorado on the road to Acapulco, and one at Cordoba. The colonies and nests do not go on forever, and the one at Tierra Colorado was in the first stages of disintegration; all cells were empty of eggs or larvae but six cells were sealed with pupae; the paper covering of the comb was badly tattered, and the three old adults on the nest were easily taken.

It was with some satisfaction that I took the nest at Cordoba, for I had seen it the year before but had no way to reach it. The memory of it had been tantalizing me for sixteen months, so it was with a feeling of triumph that I harvested the nest with the aid of a small step-ladder brought all the way from Kirkwood explicitly for that purpose. The colony was active in July 1940, as it had been also in February 1939; this indicates that establishments of this kind are more or less perennial in this climate, although the nest had not increased very much in size during the sixteen months. The cells were firmly attached to the under side of a horizontal stone beam. The comb was irregularly round in shape, made of light-weight chocolate-brown paper which had the appearance and texture of rough, crumbly cardboard, in contrast to the firm, closely-knit cardboard of *Mischocyttarus immarginatus*.

There were about fifty adults in the nest. The comb contained 315 cells; of these 160 were sealed with pupae, and 155 contained eggs or larvae or were entirely empty. The cells were narrow (eight to the inch) and were three-eighths of an inch in depth. The larvae had spun grayish-white silken caps over the cells before pupating, but the caps had not remained white for long for the workers had the strange habit of glueing tiny bits of brown paper pulp over them. They did not cover up the caps completely but scattered these adhesive crumbs here and there. The gray-white base flecked with these dark-brown crumbs gave the appearance of weathered lichens. This condition was seen in the Tierra Colorado nest also. I cannot see any utilitarian purpose for this

reinforcement or camouflage, inasmuch as these cells are not exposed to view but are covered by the curtain of paper with windows. Also, after the larvae capped the cells the workers built a ring of paper around each cap as though they were extending the cells. These rings were only  $\frac{1}{4}$  to  $\frac{1}{2}$  inch high, and would probably not have been noticed at all without the aid of a lens. It was plain that they had been placed there after the larvae had done their spinning.

Another ingenious trick, artistic or utilitarian, of *M. cingulata* is the placing of windows in the brown paper covering over the comb. The paper is not smooth, but quite crinkled and bubbly, and contains small glistening spots that look like mica. This same clever habit was observed for *Metrapolybia pediculata* in Panama (Jungle Bees and Wasps of B. C. Is., pp. 46-56, 1933), and Howes (Nat. Hist. 33:100, 1933) describes the paper nest of a *Polybia* wasp from the tropics (specific name and locality not given) "with its surface studded with tiny sheets of an almost transparent substance that admits light into the nest galleries, and reminded me of a factory with its well lighted interior."

In the nest of *M. pediculata* mentioned above, the "panes of glass" covered approximately one third of the surface, while in the nest of *M. cingulata* more than half of the area was translucent, and when held to a lamp the light streamed through these little windows. In fact, the windows were so numerous in parts of the cover that it looked very much like a beautiful piece of lace. In the present nest they did not occur in the sheet promiscuously, but in some places were thickly set in rows, and since many of these panes were built in as a sheet of glass is puttied in, it is quite unlikely that these transparent spots are due to some clear vegetable sap accidentally getting mixed with the wood pulp. If this material was accidentally mixed with the pulp we would find windows in the walls of the brood cells as well.

### ***Polybia occidentalis* Olivier**

Figures 1, 2, and 21

This wasp has attracted the attention of many observers because of its large and conspicuous bell-shaped or cylindrical paper nests. In a valuable paper, Dr. Herbert F. Schwarz, (Am. Mus. Novitates No. 471, 1931) records the nesting behavior of *P. occidentalis* var. *scutellaris* which he studied in Panama, and reviews also much of the literature on this species. I have recorded its nesting behavior in Panama (*l. c.*, 56-65, 1933), and in a recent paper (Ann. Ent. Soc. Amer., 33:81-85, 1940) I gave some details of its habits during the month of February in Mexico, where I saw several colonies in the early stages of nest founding, as well as a large colony two years old that was spending the dry season resting within the nest. In spite of all that has been written on this species, one cannot observe a colony or its nest for long, without discovering something new in the lives of these creatures.

The localities where these nests were taken were Cuernavaca and Taxco in Morelos; Acapulco, Pie de la Cuesta, Iguala and Mexcala in Guerrero; Jalapa and Vera Cruz, V. C., and at Jacala, Hidalgo. During the month of July, I saw about twenty nests, and collected ten of them for study. At that time I found them in all stages of colony formation.

Unlike other species of social wasps in Mexico, *P. occidentalis* does not have clearly defined seasons for any one of its activities; new nests and swarming, as well as heavily colonized nests, may occur at any one time.

In July I found colonies in every stage of development from the swarming stage before the new nest had even been begun, through small nests with only one comb, to nests 8 to 12 inches in length and containing as many as eight or more combs, and finally to the decline and ultimate abandonment of a huge nest by a colony that had been building it for three and one half years.

The nests were attached to man-made structures such as native huts, tourist cabins, under bridges and in culverts. and under the protection of overhanging rocks in bluffs. Some small nests were even built on the under surface of the broad banana leaves. Some were attached to trees and to woody vegetation where they were fully exposed to view, often hanging in such a way as to look like an oriole's nest. One nest high on a liana overhanging the mountain road at Xilitla actually had an orchid growing from its roof. There was much variation in the color of the nests, all the way from a light cream-yellow to a dark chocolate-brown, and sometimes a nest was mottled with various shades of tans, grays and browns; this, of course, indicated that the wood pulp was gathered from various sources.

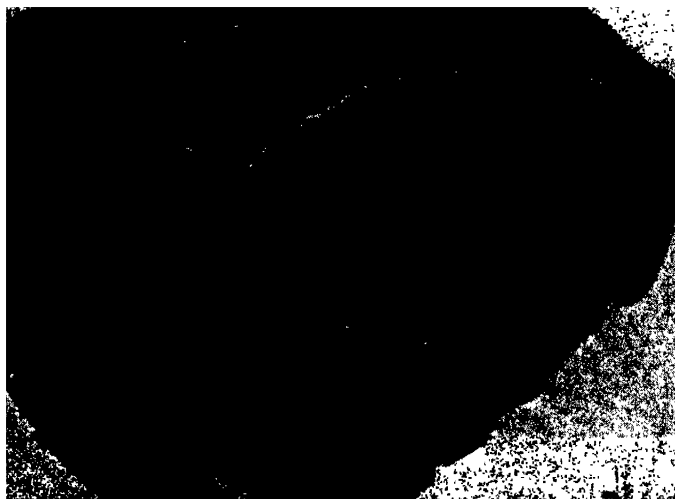
The very earliest stage in which a colony was discovered was a swarm at Pie de la Cuesta, spending the night there before going out to begin their new home. This emigrating swarm was seen at dusk, a double handful of wasps clinging close onto one another on a horizontal branch five feet from the ground. I faced a difficult decision; should I take the swarm in order to determine if it was composed of males, females or workers, or should I risk losing them in the hope of seeing them build a new nest? The latter desire prevailed—but next morning, alas! the swarm was gone, and a thorough search of the surrounding vegetation showed no evidence of nest or swarm. Hence it seems that they were merely spending the night on the branch, and had not collected to found the new nest there.

The other extreme, the decline of a colony and the final abandonment of a nest three and one half years old, was watched at Tama-zunchale, where it was under the roof above the pump at a gasoline station (Ann. Ent. Soc. Amer. 33: 81-84, 1940). The nest when I first saw it was two years old; it was bell-shaped and measured 10 inches in vertical length and the oval bottom (floor of the bell) measured 6x7 inches in diameter. This nest showed a rapid increase in size during the year and a half between my visits. The length had increased 3 inches, and now was 13 inches, while the last comb on the bottom of the nest measured 7x9 inches. Considering the fact that these additions were all on the largest parts of the nest, the growth has been more rapid than the average rate of growth during the previous time.

When we visited the nest early in July 1940 only a few wasps were on

#### EXPLANATION OF PLATE I

Figures 1 and 2. Exterior and interior of nest of *Polybia occidentalis* ( $\frac{1}{4}$  nat. size).



the outside of the nest and a few guarding the doorway, and I learned from the proprietor that the colony had been weak and inactive for two months and nest enlargement had ceased. When I returned again three weeks later no wasps were to be seen, and probing into the nest with a wire failed to arouse any response. I wanted to hold a post-mortem on the nest to learn the probable cause of the decline of the colony, but it was held in such high esteem as a beautiful and novel ornament to the station that I was not permitted to remove it.

We are in the habit of thinking of these colonies and their nests as perennial, but we find old, abandoned nests which indicate that while they may be perennial they certainly are not everlasting. One such empty nest was swinging in the breeze in a leafless tree at Iguala in February 1939. This was a large and well constructed one (figs. 1 and 2), measuring 10 inches in length and  $6\frac{1}{2}$  inches in maximum width. This nest, 25 feet from the ground, contained an enormous colony of ants, *Camponotus abdominalis* (F.) var. (det. by M. R. Smith). The tree, although leafless at that time, bore many white flowers which were frequented by the ants. We did not know the nest was occupied when we placed it in the back seat of the automobile, but an hour later the truth dawned upon us when we opened our lunch containing half of a luscious Mexican pineapple. The ants had a great propensity for migrating, and for a few days their disappearing and reappearing acts provided rather strenuous entertainment for us en route. Even after we returned home, they somehow escaped from their cage in a room on the second floor and were mourned as lost, until a caller lifted a cushion on the sofa in the parlor and revealed the colony massed beneath it. The colony thrived well in a large tin can for about six months and then began to dwindle, the last ones dying about eleven months after the nest was taken. Unfortunately I had no facilities for observing the behavior of the ants, but in September winged ants appeared in the colony.

All of the nests of *P. occidentalis* contained honey in the cells, sometimes in such large amounts that the bags in which they were placed were soon saturated with it. They also store insects in the cells and between the combs. In British Guiana Dr. Wheeler found termites stored in the nests of this species, and in Panama I found ants of the genus *Azteca* stored in three nests (*l. c.*, pp. 62-64, 1933). Again, all of the ants were males. Among ten nests examined in Mexico, only one contained stored insects; this was a nest of seven combs hanging in the arch of a culvert at Iguala. The ants were identified by Mr. M. R. Smith as *Camponotus* sp. They were also all males and badly mutilated, with all or part of the wings and legs bitten off in various places; just as *P. occidentalis* treated the *Azteca* ants in Panama. Since only one sex was taken in both Panama and Mexico, it is quite likely that ants as food are a luxury to be had only at times when nuptial flights are in progress.

The nests when small are apple-shaped (fig. 21), and only as they grow larger do they become squarely bell-shaped or cylindrical.

I found no parasites or enemies in the nests examined. In the laboratory I bred the Indian meal-worm, *Plodia interpunctella* Hbn.

(det. by Carl Heinrich), from some of the combs, but since Dr. Heinrich writes that this insect is found all over the world, I do not know if infestation occurred in its native haunts in Mexico or in my laboratory.

### POLISTES WASPS

*Polistes* wasps in Mexico have their seasons of activity and of rest. In February 1939 (*l. c.*, pp. 85-88) we found three species in the early stages of nest founding but not many colonies of any of them, for February is near the end of the dry season when all life temporarily follows a slow pace. Even then we found *P. carnifex*, *P. major*, and *P. instabilis* in the act of founding new nests. A fourth species, *P. canadensis* var. *mexicanus*, was taken on the wing and seen abundantly in the air at Cuernavaca; evidently they were at work, although nests were not seen. In contrast to the four species that were alive and at work in February—in July of the following year three of these and five additional species were observed; this makes a total of nine *Polistes* species which I know to inhabit Mexico. Doubtless the literature contains more, and others await discovery.

#### *Polistes carnifex* Fab.

Figures 3 and 4

These large nests and their giant wasps, the dread of the natives, were seen in culverts under the highway and under the eaves of buildings at Tamazunchale and Xilitla, in San Luis Potosi, Cordoba and Jalapa in Vera Cruz, and at Iguala and Acapulco in Guerrero. Large colonies as well as newly founded nests were observed in July, the new colonists evidently coming from overpopulated nests elsewhere. That *P. carnifex* has a resting or hibernating period during the dry season was observed in 1939, when no heavily populated nests could be found, but only small new ones of shallow cells with several active queens. These few queens were the forerunners, commencing their nests (probably a month before the end of the dry season) before the rank and file of *P. carnifex* became active.

The large nests are made of heavy gray paper, but all of the small new ones are of thin paper of a yellowish color. The nests always hang horizontally from a central pedicel and are usually founded by several queens. The eggs are deposited while the cells are quite shallow and incomplete, and are enlarged from time to time to accommodate the growing larvae. The completed cells are quite wide ( $3\frac{1}{8}$  to the inch). The nests of *P. carnifex* are characterized by a steep roof (fig. 3) usually sloping at an angle of about thirty degrees from horizontal; this feature becomes evident even in the small nests (fig. 4). This sloping roof is the character by which the nests of this species may be distinguished at a glance from the flat-roofed ones of *P. major*, which are otherwise very similar. The nests of *P. carnifex* are round and the largest observed—bearing a population of fifty adults—measured 8 inches in diameter. They are made of wood pulp, and adults were occasionally seen biting out bits of weather-beaten wood from posts at Tamazunchale.

***Polistes major* P. de Beavois**

## Figure 12

In February, 1939, *P. major* was taken on the wing at Tamazunchale and a newly founded nest was observed at Orizaba. During July, 1940, active colonies of *P. major* were observed at Cordoba, Acapulco, Tamazunchale, and Victoria. The nests (fig. 12) are of a single comb, round, and resemble very much those of *P. carnifex*. Nests of all sizes were observed in July, from newly founded ones with one, two, or three queens, to nests which measured up to  $7\frac{1}{2}$  inches in diameter with from 40 to 50 adults upon them. Like the nests of *P. carnifex*, the pedicel is in the center of the roof, but unlike them the roof is very flat. The nests are found under bridges and in culverts, in trees and under the eaves of dwellings. The cap over the cell is of heavy white silk and is made by the larvae before pupating. The cells are used again and again for brood, and as they become less roomy because of the accumulation of excrement left plastered to the ceilings by the succession of young, their length is often increased by the spinning larvae. Sometimes one finds the old cells in the center of the nest measuring two inches in depth, while normally they are but one inch. The cells of *P. major* are a little narrower than those of *P. carnifex* ( $3\frac{1}{2}$  cells to the inch).

Several nests of *P. major* were parasitized by the moth *Chalcoela iphitalis* Wlkr. The moths emerged from the nests in July.

***Polistes pacificus* var. *modestus* Sm.**

Nests of this wasp were found near Acapulco, Iguala, and in the village of Xaltianguis, Guerrero. The nests are small, round, and made of thin light gray paper. They hang horizontally and have the pedicel in the center of the roof. Each of the six nests taken had from 10 to 16 small (5 to the inch) cells; the cells contained eggs, larvae and pupae.

***Polistes fuscatus* var. *apachus* Sauss.**

## Figure 15

A nest of this species was found in a culvert at Rio Grande City, Texas, on July 3, 1940, and in the arid region near La Gloria, Neuvo Leon, Mexico. A dozen or more adults in company with other insects, were observed refreshing themselves at a mud puddle. With legs widely spread they deftly alighted on the water, filled their gullets and heavily flew away. The nest taken at Rio Grande City (fig. 15) was round,  $2\frac{1}{4}$  inches in diameter, and contained sixty cells with eggs, larvae or pupae and also had twelve adults on the comb. In width the cells measured a little over one-fourth inch in diameter.

**EXPLANATION OF PLATE II**

Figure 3. Nest and adult of *Polistes carnifex* ( $\frac{1}{2}$  nat. size). 4. Newly begun nests of *P. carnifex* ( $\frac{1}{2}$  nat. size). 5. Nest of *P. instabilis* ( $\frac{1}{2}$  nat. size). 6. A newly begun nest of *P. instabilis* ( $\frac{1}{2}$  nat. size). 7, 8, 9. Nests of *P. exclamans*; all of fig. 8 and part of fig. 7 parasitized by *Chalcoela iphitalis*; note condition of cells ( $\frac{1}{2}$  nat. size). 10. The work of three generations of *Mischocyttarus* sp. ( $\frac{1}{4}$  nat. size). 11. Nest of *Polistes canadensis* ( $\frac{1}{2}$  nat. size). 12. Nest of *Polistes major*; portions in center have been removed for purpose of study.





***Polistes canadensis* L.****Figure 11**

*Polistes canadensis* is not a pretty wasp to look upon; it has the dirty color of dried blood and has not even a band or blotch of color to relieve it of its ugliness. Color forms of *P. canadensis*, such as *rubiginosis*, *annularis* or *panamensis*, are quite pleasing in color or pattern.

The nests, more or less irregular in shape (fig. 11), were found at Iguala, Acapulco, Pie de La Cuesta, in Guerrero, and at Jalapa, Vera Cruz and Pola Gacho, in Vera Cruz, where they nested in trees, culverts, and under the eaves of native dwellings. Colonies are founded by several queens and in July I found nests in all stages of development. A few nests were also seen which were founded by a single queen. In reference to colony founding I may mention a very large nest with fifty adults upon it under the eaves of a native hut which had, just a few inches below it, a new nest with 104 shallow cells (each with an egg) that had only recently been founded by eight queens—presumably an offshoot from the nearby large nest.

Only six nests were obtained for study and all of them had the pedicel near the top and all hung in a vertical position. The nests are often more or less heart-shaped, owing to the tight quarters in which they are built. The largest was  $8\frac{1}{2}$  inches wide and  $4\frac{3}{4}$  inches in height. There were  $3\frac{1}{2}$  cells to the inch. Unlike some species of social wasps, but very much like that of *P. annularis*, the larva spins a silken lining to its cell which completely covers the walls from door to ceiling. The larva also often enlarges the cell before it pupates, and does this by placing an addition of silk around the opening. Many species of social wasps in temperate as well as in tropical regions strengthen the pedicel of the nest at its point of attachment by applying a shiny black substance which looks very much like rubber or tar. This substance was more freely used and more thickly spread by *P. canadensis* than by any other species of *Polistes* with which I am acquainted. In some nests the entire pedicel, including the flange which holds it to the support, was almost entirely composed of this substance and the roofs as well were covered with it. It was very thick, black and shiny near the pedicel, becoming progressively thinner towards the periphery of the roof. Not only were the wasps the first paper-makers, but apparently they also preceded man in the use of rubberized roofing as well. One nest had certain cells which indicated that the larvae were hosts to a hymenopterous parasite; none of the parasites were obtained, but their spinning work looked very much like that of *Polistaphaga fulvipes*.

***Polistes instabilis* Sauss.****Figures 5, 6, and 13**

*Polistes instabilis*, a conspicuously colored wasp, is probably the most abundant of all social wasps in Mexico. We found it everywhere in our travels—at Limon and Victoria in Tamaulipas, at Tamazunchale, Xilitla, and Valles in San Luis Potosi, at Taxco, Iguala, Acapulco, and Pie de la Cuesta in Guerrero, at Cordoba, El Fortin, Jalapa, Vera Cruz,

and Coatepec in Vera Cruz. It nests in trees, in native habitations, on walls and ceilings of culverts, under bridges and under overhanging rocks. In February, 1939, I found no large nests that were occupied, but many small nests in the early stages of founding (fig. 6) with one or more queens upon them. In July we saw nests in every stage of development, newly begun nests with from one to twelve queens upon them to fully colonized nests as large as 8 x 3 inches in diameter. Often a newly founded nest was very near to a large colony, which indicated that the new colony was merely an offshoot from the old one. Many of the shallow cells in newly begun nests contained small drops of honey. The amount of work accomplished in nest building by foundress queens is indicated by the following observations: three queens started a nest in a doorway at Tamazunchale; this and two subsequent nests built in the same place by these queens were knocked down by the owner of the place. I saw the beginning of the fourth nest as I was leaving Tamazunchale, and when I returned eighteen days later I found that the three queens had built a fourth nest during that time. This was 3 inches long and  $\frac{1}{2}$  inch wide, and had 41 shallow cells which contained eggs.

The nests of *P. instabilis* are more or less pear-shaped (fig. 13) although they are sometimes diamond- or finger-shaped (fig. 5); they hang in a vertical position and have the pedicel at the very top. Many nests have the pedicel and a portion of the comb near it more or less thickly covered with the black rubbery substance described for *Polistes canadensis*; one small nest had an extremely heavy coating of it on the top, sides, and back of the nest. The number of cells to the inch was four to four and one-half.

This species suffered very much from the onslaughts of the lepidopterous parasite *Chalcoela iphitalis* Wlkr. Out of 56 nests collected, 24 were parasitized, and these to the extent of from 10 to 100 per cent of the cells.

### ***Polistes exclamans* Viereck**

Figures 7, 8 and 9

*Polistes exclamans* is not a Mexican wasp, but deserves to be included in this list since it is found close to the Mexican border. Colonies were observed in Texas at Rio Grande City, Austin, Artesian Wells, Denison, Mission, Pleasanton, Sherman and Waco. *P. exclamans* resembles *P. instabilis* very much in color and form, but there is a slight difference in the shape of the nests. There are also slight anatomical differences, for Dr. Bequaert writes: "The specimens which I have called *exclamans* are all from Texas, while those which I have called *instabilis* are all from Mexico. The two species are exceedingly similar. It is possible to distinguish between the males without much doubt, but females and workers can scarcely be told apart; there is, however, a slight difference in the shape of the head; the eyes in *P. instabilis* females being more bulging than in the *P. exclamans* females."

This species nests in culverts, under bridges, in thickly matted vegetation as well as in sheds, porches and under the eaves of buildings. Nests in all stages of development were found on July 3 in our drive

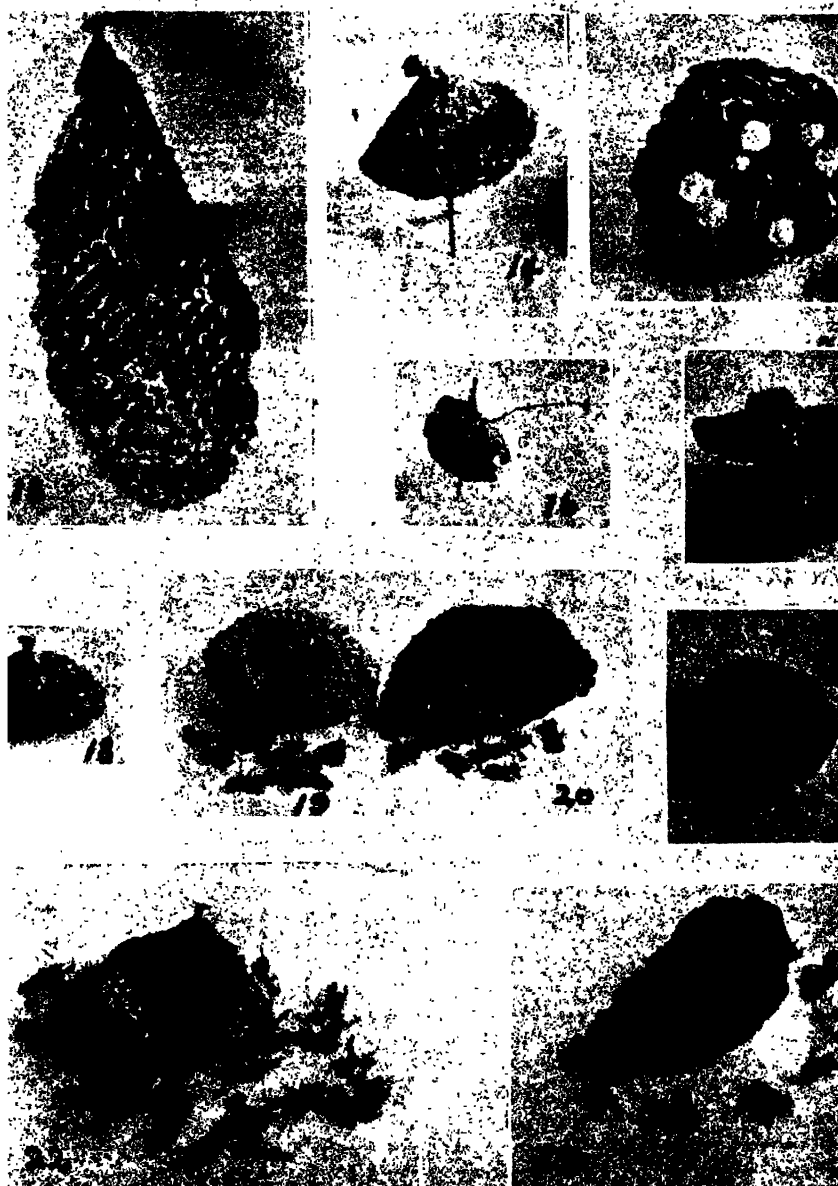
from Mission to Rio Grande City; some were small and newly founded with one or a few queens, and some were quite large. The largest, which was fan-shaped because of the crowded corner in which it was built, measured  $4\frac{1}{4} \times 3\frac{1}{4}$  inches in diameter. Most of the nests measured roughly about  $3 \times 2$  inches in diameter. Even though the summer was only half over it was evident even at this time that this species does not make nests of giant size; of the large number of empty last seasons' nests collected the largest measured only  $4 \times 5$  inches in diameter. Here too, as is so common with tropical *Polistes*, swarming and pleometrosis occurs; almost all of the newly founded nests were very close to large colonies from which they evidently had their origin, and almost all of them were founded by several queens. Most of the nests were attached to flat surfaces, but in an open shed at Rio Grande City I found three large nests hanging from a wire which was tightly stretched near the ceiling. In the same shed I found also a large misshapen nest with a hundred wasps upon it, crowded under the handle of a piece of machinery, and just a few inches below it a newly founded one of shallow cells with 50 adults upon it. Whereas the nests of *P. instabilis* are almost always pear-shaped and hang in a vertical position (figs. 5, 6, 13), those of *P. exclamans* are almost always round or irregularly round, or irregularly oblong (figs. 7, 8, 9), and even though the pedicel is at the edge of the roof the nest usually hangs in a horizontal position. The pedicel of the nests of this species is only slightly rubberized. The number of cells to the inch varied from  $4\frac{3}{4}$  to 5. Several cells in several of the nests contained drops of honey. When the adults of the colonies were examined on July 3, I found many males among them.

Many of the nests of *exclamans* were parasitized by the moth *Chalcoela iphitalis*, and in some nests the infestation was as much as 95 per cent of the cells (fig. 8). The moths emerged as adults during July.

The larvae of this wasp secrete an enormous amount of silk; not only do they spin the silken caps to the cells, but they also thickly line the paper walls of them to the very ceiling with it, and also often increase the size of the cell by adding a ring of silk to it. It seems to me that a study of the spinning activities of social wasps would reveal facts of great phylogenetic significance, since the solitary wasps (Sphecidae) from which they evidently have evolved are known to spin silken cocoons.

#### EXPLANATION OF PLATE III

Figure 13. Nest of *Polistes instabilis*; lower cells parasitized by *C. iphitalis*; upper cells resealed with mud, leaf-paste or resin, by *Stenodynerus mystecus*, *Zethus pipiens* and *Megachile* sp., respectively ( $\frac{1}{2}$  nat. size). 14. Nest of *Mischocyttarus immarginatus*, showing layer of waterproof substance on roof near pedicel ( $\frac{1}{2}$  nat. size). 15. Nest of *Polistes fuscatus* var. *apachus* ( $\frac{1}{2}$  nat. size). 16. Nest of *Mischocyttarus labiatus*; note long, thin pedicel ( $\frac{1}{2}$  nat. size). 17. The work of two generations of *Mischocyttarus* sp. ( $\frac{1}{2}$  nat. size). 18. Nest of *M. pallidipectus* ( $\frac{1}{2}$  nat. size). 19. Nest and adults of *M. basimacula* ( $\frac{1}{2}$  nat. size). 20. Nest and adults of *M. immarginatus* ( $\frac{1}{2}$  nat. size). 21. A newly begun nest of *Polybia occidentalis* ( $\frac{1}{2}$  nat. size). 22. Nest and adults of *M. cubensis* var. *mexicanus* ( $\frac{1}{2}$  nat. size). 23. Nest and adults of *M. ater* ( $\frac{1}{2}$  nat. size).



## MISCHOCYTTARUS WASPS

All members of the genus *Mischocyttarus* build nests of paper but in some species the finished product is light-weight and papery, resembling somewhat in texture the nests of *Polistes* wasps, while in others the comb is smooth, firm, brittle, closely-knit and looks very much like stiff thinly glazed cardboard. In the latter instances the pulp which goes into the making of the nest is evidently subjected to a more thorough process of mastication with probably, also, a more liberal amount of saliva or other important ingredients added.

In Mexico those species which I observed that make papery nests are *M. pallidipectus* and *M. basimacula*. Those which make cardboard nests are *M. immarginatus*, *M. ater*, *M. cubensis* var. *mexicanus* and *M. angulatus* var. *ictezicus*. There is another species, *M. labiatus*, that make a nest whose texture is of an intermediate grade, for while it resembles rough cardboard, the material is so thinly spread and so loosely put together that it cannot be placed in either of the two categories.

In tropical regions of Mexico such as Cordoba and Tamazunchale, one would expect to find colonies of social wasps such as these to be perennial, *i.e.*, existing from year to year and throwing off the surplus population in swarms as "lebensraum" demands it. This, however, is not the case for these wasps, for while they lose a portion of the population from time to time for the founding of new nests, the colonies themselves come to an end before the coming of the dry season, and the survivors that are to perpetuate the race go through a resting period which is probably very much like the hibernation of northern wasps. This period of hibernation in Mexico coincides with the dry season which ends in May; however, long before the end of the dry season some members of some species come out of their torpor and found new nests. This was found to be true for four species of *Mischocyttarus* wasps which began their nest building in February (Ann. Ent. Soc. Amer., 33: 82-92, 1940).

In July 1940 I found the nests of members of this genus much more abundant, of much larger size, and with larger populations upon them than in February 1939, when the nests were first begun. Naturally one would expect this to be the case, but it is here mentioned since it points to a seasonal activity instead of a perennial condition.

In addition to renewing my acquaintance with the four species seen in 1939 (*M. immarginatus*, *M. ater*, *M. basimacula*, and *M. cubensis* var. *mexicanus*), three additional species, *M. pallidipectus*, *M. labiatus*, and *M. angulatus* var. *ictezicus*, were observed, making a total of seven species in my experience with Mexican *Mischocyttarus*. It is to be regretted that time was not at hand to study the minute details of behavior of the various species, for they offer to the naturalist many problems in behavior, phylogeny and ecology, which may only be solved by residence in one place for several weeks or by frequent visits to certain nests over long periods of time. Some of the problems to intrigue one are: How, why, and when do they hibernate? What is the caste system, if any? What materials go into the building-pulp and how is it manipulated by each species? To what extent is honey

used as food for the young and what insects, if any, are used as food for the young? If insects are used how are they captured and transported to the nest? These and many other problems offer a rich field to the young and enthusiastic naturalist. However, all is not in complete darkness; some few details on life history have been observed on seven species of these wasps, as the following pages indicate.

### ***Mischocyttarus pallidipectus* Sauss.**

#### Figure 18

Three nests of this wasp, a black insect with delicate yellow bands on the abdomen, were found on the underside of the bridge spanning Rio del Tecapulco, near Iguala, Guerrero. The nests (fig. 18), (each a single comb, with the pedicel at the edge of the roof) were constructed of light-weight brown paper and hung horizontally. They were round or oblong in shape and the three nests measured  $\frac{1}{2} \times \frac{7}{8}$  inch in diameter,  $\frac{7}{8} \times \frac{7}{8}$  inch and  $1\frac{1}{2} \times \frac{7}{8}$  inches, respectively. The nests contained 17, 25, and 30 cells. In measuring the width of the cells I found that there were six to the inch. There were only one or two adults upon each nest, and it appears that this species commences nest building late in the season. I do not think that colonies of this species ever attain great size.

### ***Mischocyttarus labiatus* Fab.**

#### Figure 16

The nest of this species never attains great size; it is merely a small cluster of *Polistes*-like cells dangling from a long, thin, wire-like pedicel (fig. 16). The pedicel is attached to the center of the roof. Two of the nests of this species were removed from overhanging rocks along the road next Xilitla, San Luis Potosi, on July 8. There was one adult on each nest, but both flew away when an attempt was made to obtain them. Since no specimens were taken I cannot be absolutely sure about the accuracy of the identification; however, the nests and adults looked very much like the *M. labiatus* whose acquaintance I made in Panama some years ago (Jungle Bees and Wasps of Barro Colorado Island; fig. 62). Both nests were round, contained 16 and 26 cells respectively, measured an inch in diameter, and hung bell-like from a thin strong pedicel  $1\frac{1}{4}$  inches long. The pedicel was not composed of the same material as that of the nest, but seemed to be very much like the rubbery material used for pedicel reinforcement by *Polistes* wasps, mentioned in previous pages. The nest itself was made of roughly masticated wood pulp of gray and brown color (both colors appearing in each nest) having mixed with it bits of unchewed wood which was easily discernible with the hand lens. This same condition of rough grains and bits of unchewed wood in the building material was also noticed in the Panama nests already referred to.

### ***Mischocyttarus ater* Olivier**

#### Figure 23

At Cordoba in February 1938 I found a single queen in the act of building her first cell (*l. c.*, p. 90), and in the immediate vicinity of this

nest I found in July 1940 two fairly populous colonies of this species. The wasps are large in size when compared with other members of the genus, and have black bodies with black wings. The only relief from somberness is an area of dirty white on the tip of each wing. This is at first not noticed, but the lighter area soon looms up conspicuously when the wasps nervously flit the wings as they move about the nest. I noticed that the wings were often half raised and were flitted so often and so jerkily and with what appeared to be conscious effort, that I concluded that this was done for my benefit as well as to serve as a warning signal to other members of the colony.

The nests, solidly made of finely masticated cardboard, are dark brown in color and serve admirably as a protectively colored background for the black wasps, for the white tips of the wings are not at all prominent as they normally move about the nest. The nests were in horizontal positions attached by short stout pedicels to the stone arches of an old building (fig. 23). The smaller nest, composed only of shallow cells with six queens upon it, was in the early stages of founding, and the colony had evidently swarmed from the larger nest twelve feet away. I arrived at this conclusion because the larger nest seemed to be at the point of breaking up, for even though there were 23 adults upon it there were only a few immature wasps in the cells (most of the cells were empty) and no new cells were in course of construction. The larger nest was irregularly semicircular (evidently due to the fact that it had been started too near to the pillar of the arch) and measured at its widest points  $2\frac{1}{2} \times \frac{1}{2}$  inches in diameter. There were about 95 cells in the nest and these measured five to the inch.

Judging from the observation in 1939, one may aptly say that the present large colony had its inception late in the dry season (perhaps also in February), and after developing for five months was in the final stages of decline and disbandment. With the end of the season yet several months away, the newly founded nest indicates that colony founding and development will continue for sometime. Instead, therefore, of having at the end of the season one large colony, we will have a number of small ones; all offshoots more or less remote from the main nest. Just why several small colonies should be better than one large one is anybody's guess. To me, at least, one method does not seem to have any advantage over the other for, quite likely, the number of queens which go into hibernation at the end of the season will be the same either way.

### ***Mischocyttarus basimacula* Cameron**

Figure 19

Colonies of *M. basimacula* were taken in July at Cordoba, Jalapa and Coatepec in Vera Cruz, and in February of the previous year a newly founded nest of 42 cells and 3 queens was taken at Tamazunchale (*l. c.*, p. 90). The nests of this wasp are made of thin brittle paper and are of a pale yellow color, matching almost completely the yellow color of the wasps. One only realizes how closely the wasps resemble the nests when one attempts to take them. The nests (fig. 19) are round or irregularly oblong and do not attain great size; the largest of the eight nests taken measured  $1\frac{3}{4} \times 2$  inches in diameter, and contained about

60 cells. The cells are not very wide (seven to the inch). Colonies are founded by one or many queens, and newly founded colonies were seen in July as well as (as already mentioned) in February. The number of adults on the nests in July was quite large, and the 60-cell nest referred to above had 22 adults upon it when taken. The nests were attached to walls of culverts and sometimes to old paper nests of their own and of other species. Three of the eight nests taken were parasitized by the moth *Chalcoela iphitalis* Wlkr., the infestation amounting to 10, 25 and 50 per cent respectively of the immature population.

***Mischocyttarus angulatus* var. *ictezicus* Richards**

Three nests of this species were taken under bridges over Rio de Tecapulco near Taxco, Guerrero, and Rio Popagayo on the road to Acapulco. The adult wasp is small and of a yellowish color and the nest is made of stiff brown paper. The nests in the middle of July were small, having only from 8 to 15 cells and with only from one to five adults on them. It is not known if pleometrosis exists in this species.

***Mischocyttarus cubensis* var. *mexicanus* Sauss.**

Figure 22

Four nests of this species were taken at Valles, San Luis Potosi, and Iguala, Guerrero, although in the previous year in February they were taken at Limon and Victoria in Tamaulipas (*l. c.*, 90-91), where they were in the early stages of nest founding. The nests (fig. 22) are made of light-weight cardboard and hang in horizontal positions. The shape of the nest may be round or oblong, with the pedicel placed near the edge of the roof. One round nest measured  $1\frac{3}{4}$  inches in diameter and on July 6 had 30 adults upon it; another, an oblong one, measured  $1\frac{1}{2} \times \frac{1}{2}$  inches in diameter and had 7 adults upon it; the third, with 10 adults, measured  $2 \times 1$  inches. The cells measure 6 to the inch. Apparently new nests are begun at any time of the season, for we found newly founded nests in July 1940, as well as in February of the previous year.

***Mischocyttarus immarginatus* Richards**

Figures 14 and 20

This is the new species recently described by Dr. O. W. Richards, in part from material collected by me in February 1939. A technical description of the species appeared in *Annals and Mag. of Nat. History*, Series 11, 5: 182-183, 1940, and an account of its nesting behavior in *Annals Ent. Soc. America* 33: 91-92, 1940. On my first visit to Mexico, colonies of this wasp were observed at Canyon de Galana, Valles, Victoria, Tamazunchale, and Cordoba. In July 1940 they were observed at Xilitla and Tamazunchale, in San Luis Potosi, Taxco, Iguala, Mexcala, Acapulco, and Pie de La Cuesta in Guerrero, Limon and Victoria, in Tamaulipas, and Cordoba in Vera Cruz, and Richards (*l. c.*, p. 83) records it also from Chichen Itza, Yucatan, and from Managua, Nicaragua.

The nesting sites of this species are in culverts under the highway, under bridges, under overhanging rocks, in the eaves of native huts, in



the doorways and window frames of modern tourist camps and in open faced sheds. The nests were quite large in July; this was to be expected, since building operations commence during the latter part of the dry season. The nests are founded by one or by several queens and the size of the nest is probably in proportion to the number of queens which found it. The shape of the nest is round, oval, or oblong, but one often finds a nest of irregular shape (fig. 20) due to the cramped quarters in which it is placed. When operations are started too close to a wall the result is a nest which is semicircular; when it is commenced in an angle of two walls the resulting nest is fan-shaped; when placed in crevices among rocks the finished nest is very much mis-shapen. The nests always hang in a horizontal position and are attached to the supports by a short stout pedicel, usually centrally placed on the roof of the nest, but sometimes placed considerably off center. The size of 22 nests collected in July varied from approximately  $2 \times 1\frac{1}{2}$  inches in diameter to the largest which measured  $3\frac{1}{2} \times 2\frac{1}{2}$  inches; most of the nests, however, measured about  $2 \times 1\frac{1}{2}$  inches, more or less. These measurements do not include the small newly founded nests, several of which were seen at the time. The season had yet several months to go before its end, and the colonies as well as the nests would have become larger before the coming of the dry season had they not been disturbed. However, the largest nest taken from last year's crop measured only  $4\frac{1}{2} \times 4\frac{1}{2}$  inches in diameter, and it is doubtful if nests of this species ever attain greater size.

The nests are solidly and substantially built, and the finished comb resembles smooth cardboard. So closely-knit is the pulp that one suspects it is thoroughly worked up in the mouth and heavily mixed with saliva before being used as building material. One sometimes wonders if vegetable gums are not also used in the process, for the finished product is so much in contrast with similar work of a sister species, *M. labiatus*.

The roofs of the nests are undoubtedly made waterproof by the spreading of a substance which I think is saliva mixed with certain vegetable juices. This hardens into a thin, transparent, shiny layer of onion-skin-like substance which may be picked off in small patches with a pin point (fig. 14). In some nests, however, this roofing veneer is so thin that one needs a hand lens to see it. It was at first thought that this material was a silk substance, but the microscope proved it to be not so. In one nest in particular this layer was unusually thick around the pedicel and actually entirely covered it. It covered the entire roof also, but became progressively thinner as it neared the edges, and yet still thinner as it went over the edges and spread over the outside row of cells, where (thin as it was) it was still sufficiently shiny to be easily recognized. Sometimes the roofs were thickly covered with this hardened spittle, sometimes thinly so, and sometimes it did not appear at all. Since all of the nests were taken from amply protected situations in man made structures, I suspect that the behavior of waterproofing the roofs—if that is what it actually is—is a vestige from the time when the wasps were compelled to place their nests in positions exposed to the elements.

The wasps of this species return to the home site after hibernation and found new nests near the old ones. They sometimes even attach the new nest onto the old one. Nests of this kind may be seen in figures 10 and 17, where three and two annual generations respectively have built in this manner, and other cases of this kind may be seen in Ann. Ent. Soc. Amer., 33: 93, 1940, figures 1 and 2. It is of interest to note that like *Polistes* wasps, this species never uses a nest for a second season, and also like *Polistes* wasps, they always gather fresh building material for each nest, instead of obtaining it the easy way by dismembering and rechewing the walls of a nearby old nest.

The larvae of this species, like those of all social wasps, spin silken caps over their cells before pupating. In *Polistes* wasps, these caps are always conspicuous by their whiteness. In *M. immarginatus*, however, the caps are of the same brown color as the rest of the nest. The workers are responsible for this color condition, for it was noticed that the newly spun caps are white, and that after a time the workers cover them with a thin layer of brown saliva which probably contains dissolved wood pulp. The larvae spin caps that are very thin, and the additional layer probably serves to conserve moisture for the larvae. The number of adults on the nests in July varied from 12 to 25.

The cells were about one-half inch deep, and in width there were  $5\frac{1}{4}$  to  $5\frac{1}{2}$  cells to the inch.

The nests of this species were free from the lepidopterous parasite *Chalcoela iphitalis*, which is a menace to other social wasps in Mexico. An enemy of this species, I was told, is a marauding ant, which occasionally completely exterminates a colony.

## EUMENIID WASPS

### *Odynerus pratensis* Sauss., and *O. verus* Cress.

In the arid region north of La Gloria, Neuvo Leon, several dozen wasps of both *O. pratensis* and *O. verus* in company with the similarly colored *Polistes fuscatus* var. *apachus* frequented a water puddle near a well, where they quenched their thirst and also carried away great gullefuls of water. Several species of Lepidoptera, as well as several individuals of a small *Trypoxylon* wasp were there, also refreshing themselves. The Eumeniids always alighted on the surface of the water with outstretched legs, and they remained in this position for several minutes without any fatalities occurring.

### *Odynerus hidalgo* Sauss.

Two dead specimens of this species were found in old cells of the mud-dauber, *Scelephron caementarium*, taken near the Mexican border at McAllen, Texas. These wasps, like so many sister species, use the cells of discarded mud nests for their own young.

### *Pachodynerus nasidens* Latr.

A wasp of this species was taken on flowers at Tierra Colorado, Guerrero, July 15, 1940. Dow (Psyche, 39: 12, 1932) found this wasp in Cuba nesting in the discarded cells of the mud-daubing wasp. He

reports that caterpillars are used for food for the young, that the egg is suspended in the cell by a silken thread, and that the cocoonless larvae cover the walls of the cells with a transparent layer of shiny silk.

***Ancistrocerus bravo* Sauss.**

One adult emerged from an old cell of the mud-dauber, *Scelephron* sp., on August 2, 1940. The nest was taken a few weeks earlier near Jalapa, Vera Cruz.

***Ancistrocerus guzmani* Sauss.**

At twilight on the road to Vera Cruz, an aggregation of six of these wasps, all males, was found asleep on a delicate rootlet protruding from a bluff. The rootlet was in a vertical position and the wasps were strung on it one below the other, all with heads up and about an inch apart. On a parallel rootlet a few inches away was another aggregation of a half dozen wasps, all males, but of another species, *Chalybion zimmermanni*. The latter species has cuckoo-like habits. It is noteworthy that even though the sleeping quarters were close to one another, there was no mingling of the species.

***Stenodynerus mystecus* Sauss.**

Figure 13

This species uses the old empty cells of *Polistes instabilis* and of *Mischocyttarus* sp. as brood chambers for its young. It is a worker in mud, using this material for making partitions and for sealing the entrances. The cells in the *Mischocyttarus* nests measure three-eighths to one-half inch in depth, and an entire cell is used for each young. The cells are considerably larger, however, in the nests of *P. instabilis* and one cell usually serves for two brood chambers when a mud partition is placed across the middle. Sometimes, however, the mud wall is placed a little distance from the entrance; in such cases there is a vestibule or empty air pocket near the plugged opening; sometimes the wall is placed near the ceiling, and then the little room entombs the rubbish left in the cell by a previous occupant.

The larvae feed on caterpillars provided in mass provisioning by the mother; in each of six cells in which the eggs failed to hatch I found from 12 to 16 very small caterpillars. These were so lightly stung (or probably not stung at all) that many of them pupated; later some of the latter actually transformed into adults. The adults were identified as *Scythris* sp. (Scythridae) (det. by J. F. Gates Clark).

Many species of Eumeniid larvae, before preparing for pupation, apply a thin veneer, probably of silk, to the walls of the cells. The walls are covered more or less completely according to the species, but in *S. mystecus* the amount of veneering is indeed very small and is wholly confined to the inside portion of the plug or the partition, which, incidentally, happens to be the point nearest the mouth of the larva.

*S. mystecus* were only found near Iguala and Mexcala, Guerrero. In a large old nest of *P. instabilis*, 20 cells were used by *S. mystecus* and in the three nests of *Mischocyttarus* sp., 27, 30 and 110 cells respectively were used by this Eumeniid wasp. The nest with 110 cells, however,

was the crowning glory of the series for it gave forth 93<sup>2</sup> adults which emerged between July 15 and 30 with, in addition, a few stragglers emerging between September 1 and 22. Many fully developed wasps were unable to break their way through the mud plugs, although when the plugs were examined it was evident that attempts were made by the young adults to bite their way to liberty. This difficulty in emerging might be due entirely to laboratory conditions, for each nest was kept in an almost airtight cellophane bag; under natural conditions enough moisture would have been absorbed by the mud to make normal emergence possible.

*S. mystecus* seems to be easy prey for several species of parasites. Several chalcid parasites, *Monodontomerus montivagus* Ash. (det. by A. B. Gahan) emerged from the cells August 28 to September 5. A fully formed dead braconid parasite, *Bassus gibbosus* Say (det. by C. F. W. Muesebeck) was found in one of the cells among dried caterpillars; according to Dr. Muesebeck, *B. gibbosus* is only parasitic on lepidopterous larvae, and it is assumed, therefore, that the host was the caterpillar prey, *Scythris* sp. and not the wasp larva. Two cuckoo-wasp parasites, *Chrysis* sp., emerged from the cells on July 15 and 20. A dipterous predator, *Toxophora virgata* O. S. (det. by C. T. Greene) emerged from one of the cells on August 3, and a dead adult dipterous predator, *Leucopis* sp. (det. by C. T. Greene) was found in one of the cells.

#### ***Zethus aztecus* Sauss.**

One specimen was taken on a flower at Limon, Tamaulipas, July 25, 1940.

#### ***Zethus pipiens* Zavattari**

Figure 13

This species, like *Stenodynerus mystecus*, uses the empty cells of *Polistes* and *Mischocyttarus* nests as brood chambers for their offspring. They gather and use a green vegetable material, which they thoroughly masticate, for partitioning the cells and plugging the openings.

*Z. pipiens* and *S. mystecus* often use the same paper nest at the same time for their broods, but the work of each can easily be identified because one uses green vegetable pulp and the other uses yellow mud. The green vegetable material used by *Z. pipiens* is thoroughly worked over and when dry is as hard as the mud plugs of *S. mystecus*. In several nests I found cells of both species side by side, but in every case the cells of *S. mystecus* greatly outnumbered those of *Z. pipiens*. In two of the nests a third insect—a resin-using *Megachile* bee (new species)<sup>3</sup> occupied some of the old cells.

The nests containing *Z. pipiens* were found only at Mexcala and Acapulco, Guerrero. The nests were collected during the middle of July and adult wasps emerged 10 to 14 days later. Three nests disclosed 13, 6, and 3 *Z. pipiens* respectively, and several of them in each nest were unable to bite their way through the hardened plugs of leaf paste.

<sup>2</sup>Dr. Bequaert has kindly examined the 93 wasps to ascertain the proportion of sexes. He reports 44 males and 49 females.

<sup>3</sup>A description of the new species is soon to be published by Dr. T. B. Mitchell.

The brood-chambers in the old *Mischocyttarus* nests were near the ceiling, and consumed about two thirds of the available space, while the lower third near the doorway was unoccupied and appeared to be an air chamber. When the larger cells of *Polistes instabilis* were used the brood chambers of *Z. pipiens* (three-eighths inch in length) were near the openings, and the rest of the cell walled off with a plug of leaf pulp one sixteenth inch thick.

The old cells of *Mischocyttarus* sp. are used over and again, generation after generation, by *Z. pipiens*; the young wasps evidently build in the very cells from which they emerged. This same behavior was also recorded for its neighbor *S. mystecus*, and sometimes a cell is used one year by one species and the next year by the other, for we often found exit holes in mud plugs which were resealed with green leaf pulp—indicating that after *S. mystecus* had bitten its way to freedom along came a mother *Z. pipiens* and appropriated the cells for her own brood, leaving the telltale bit of green in the doorway.

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STONEFLIES OF SOUTHWESTERN BRITISH COLUMBIA, by WILLIAM E. RICKER. Indiana University Publications, Sci. Ser. No. 12, 145 pages, 129 figures. 1943. For Sale, Ind. Univ. Bookstore, Bloomington, Ind. Price, \$1.50.

Professor Ricker, now of the Zoology Department of Indiana University, is well known in his various studies of Canadian stoneflies, first while at the University of Toronto and later in British Columbia while serving the Fisheries Research Board of Canada and (1938) the International Pacific Salmon Fisheries Commission.

The present study is one of the most complete and detailed yet made of the stoneflies of a small area. While in taxonomic form it considers types of streams, water temperatures and seasonal distribution. Forty-four pages are devoted to the general problems of the plecopterous fauna of that region, and the problems of its classification. Pages 45 to 142 are devoted to keys and descriptions of species. In the final study of species the author had the use of the extensive collections of the Illinois Natural History Survey.—C. H. K.

THE LEAFHOPPERS OF MINNESOTA (HOMOPTERA: CICADELLIDAE), by JOHN T. MEDLER. University of Minnesota Technical Bulletin 155, June, 1942, 196 pp., 9 plates.

This bulletin is presented with the hope that it will serve as "a convenient and useful manual for the systematic and economic worker concerned with the forms of the upper Mississippi Valley." References to the original description are given for each name used, and keys presented for separation of species, genera and supergeneric groups. A brief diagnostic description of each species appears with distribution and host records. In addition to the systematic treatment there is a list of the literature cited and indices of plant and leafhopper names are included.

The arrangement with respect to subfamilies initiates use of a number of names new in this category. Mr. Medler acknowledges the assistance of Dr. P. W. Oman in his arrangements and that it is in part drawn from Dr. Oman's unpublished work. However it seems unfortunate that inasmuch as some of the changes are rather drastic, no explanation as to why they are so used is offered.

By bringing into readily available form records on the leafhopper fauna of this region, the bulletin will undoubtedly fulfill the hope of its author as expressed above.—DOROTHY J. KNULL.

# ANATOMY AND HISTOLOGY OF THE FEMALE REPRODUCTIVE ORGANS OF HABROBRACON JUGLANDIS (ASHMEAD)

(Hymenoptera, Braconidae)<sup>1</sup>

JOSEPH CHRYSTAL BENDER,  
Summit, New Jersey

The development and the morphology of the ovaries of *Habrobracon juglandis* (Ashmead) have been described in some detail by various investigators (Genieys, 1925; Henschen, 1928; Speicher, 1931; Whiting, 1940). Of the other organs of the female reproductive system, or "Geschlechtsapparat," no adequate account could be found in the literature. The author's original intention, that of studying the development of these other components of the reproductive system, was therefore abandoned for the time being, in favor of a detailed study of their gross and microscopic anatomy. It is hoped that this study may in part better familiarize those interested in this insect with the morphology of its reproductive organs.

The organs that, in addition to the ovaries, comprise the female reproductive organs are the spermatheca and spermathecal glands, the lubricating gland, the poison glands, and the sting itself. Although these organs are, in their general morphology, typical of Hymenoptera, they differ in many details of structure and arrangement.

The illustrations in this paper should be considered an integral part of the study, for in many cases they speak much more clearly than the text.

Throughout this paper where homologies have been recognizable between *Habrobracon* and other related forms, I have employed the terminologies as set forth by Snodgrass.

## MATERIALS AND METHODS

The material used for observation consisted of two wild-type stocks No. 25 and No. 33, which were reared in incubators at 28° C. at the University of Pennsylvania Zoological Laboratory.

Dissections of freshly killed females were made in insect Ringer's solution<sup>2</sup> under the Greenough binocular at a magnification of 50×. A small drop of Tergitol added to the Ringer's at the time of dissection greatly facilitated operations by cutting down surface tension on the cuticle. A foot-focusing device was found to be of much assistance. Operations were usually performed by snipping off the abdomen, cutting away the cuticle with micro-scissors, and dissecting with two

<sup>1</sup>The author wishes to acknowledge his gratitude to Dr. and Mrs. P. W. Whiting for supplying the insect stocks used in this study, to Dr. A. G. Richards for helpful suggestions, and to Dr. R. G. Schmieder for his generous assistance and advice.

<sup>2</sup>Formula by Ephrassi and Beadle for insect Ringer's solution: NaCl, 7.5 grams; KCl, 0.35 grams; CaCl<sub>2</sub>, 0.21 grams; H<sub>2</sub>O, 1000 cc.

pairs of extremely fine, No. 5, Swiss watchmaker's forceps. These were found to be useful because the tracheae, woven tightly in and around the organs in question, could be carefully torn away without disturbing the other organs.

Whole mounts were often prepared from such dissections by fixing in Kahle's (F. A. A.) or B-15, staining in either haemalum or alum cochineal, dehydrating in alcohols, clearing in cedar oil, and mounting in balsam. Whole mounts stained in Sudan III (in 70% alcohol) were run quickly down the alcohols to water, mounted in Apathy's gum syrup.

Sectioned material was fixed in Kahle's or in B-15. Since only certain abdominal organs were to be observed, the entire abdomen was cut off and most of the body wall removed. Dehydration and clearing were accomplished by the regular alcohol-xylol method, specimens imbedded in paraffin and then sectioned at 8-10 $\mu$ . Slides were stained with Delafield's haematoxylin, Heidenhain's haematoxylin, Mallory's Triple, and by the Feulgen method.

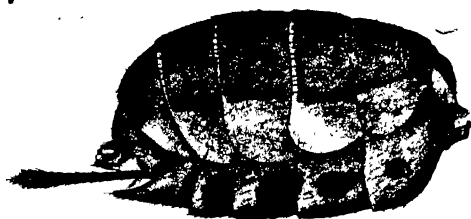
### EXTERNAL STRUCTURES

*Ovipositor and Associated Parts.*—Externally the abdomen of the female exhibits eight tergites and five sternites (fig. 1). The first tergite actually represents the tergite of the second abdominal segment, for the first segment (propodeum) is combined with the thorax. The first sternite is composed of the second and third segments fused together. The ovipositor extends from the end of the abdomen, between the proctiger and the seventh sternite. The seventh sternite, known as the subgenital plate, projects slightly caudad beneath the base of the ovipositor. The ovipositor is made up of three pairs of valvulae: the first pair are lancets, the second pair are fused into a median sheath, the third pair are palpi. Externally, only the third valvulae are visible, for they ensheath the first and second valvulae between their hollowed inner surfaces. Together the first and second valvulae present a single dart-like structure, known as the sting. The first valvulae are grooved on their dorsal surfaces and ride on rails of the second valvulae (fig. 2A). The distal ends of the first valvulae are barbed (fig. 3) and lie together not attached to the second valvulae but partially ensheathed by them (fig. 2B). The distal tip of the fused second valvulae is somewhat enlarged and slightly decurved. The first and second valvulae are so constructed as to form a space between them, the poison canal (figs. 2A and 2B), through which both the poison and the eggs pass to the outside. The other cavities seen in these valvulae are extensions of the body cavity and do not open externally. Embryologically, the second valvulae arise as two distinct parts which fuse into one, as is shown by the two cavities of the undivided second valvulae meeting toward the tip.

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### EXPLANATION OF PLATE I

FIGURE 1. External view of abdomen. 2A. Cross-section through 1st and 2nd valvulae, at center. 2B. Cross-section through 1st and 2nd valvulae, at tip. 3. Details of 1st and 2nd valvulae. 4. Sagittal section of female abdomen, showing relationship between organs of the sex apparatus.



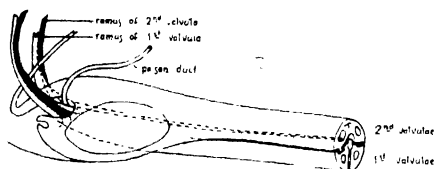
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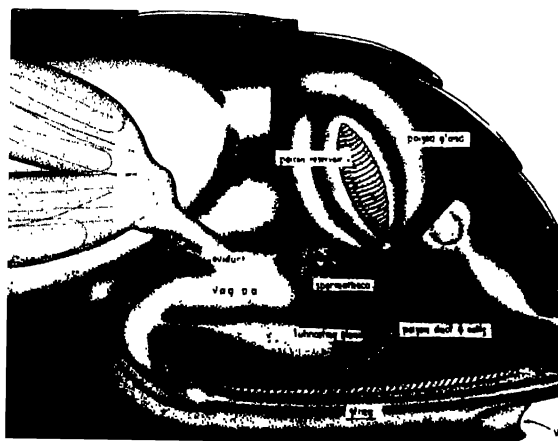
2-A



2-B



3





A cavity, the vestibulum (fig. 4) leads cephalad under the bases of the valvulae above the seventh sternite. The vestibulum arises embryologically from the caudad extension of the seventh sternite (Snodgrass, 1933). This cavity continues anteriorly above the two most posterior sternites. The bases of the third valvulae, which lie in the vestibulum, are known as the second valvifers (fig. 5). The anterior end of each second valvifer makes a dorsal and then a posterior turn on itself, thus presenting a somewhat triangular projection. Along the posterior aspect of this triangular plate is another small plate, the first valvifer (fig. 5). On the dorsal aspect of this plate articulate two large but thin chitinous lateral plates (fig. 5). These are the anterior continuations of the ninth tergite and they laterally overlap the second valvifers.

Between the anteriormost portions of the second valvifers, which are there somewhat flattened out and curved in towards each other, lies the enlarged proximal end of the second valvulae, the bulb (fig. 5). The bulb is formed from the enlarged bases of the second valvulae, each of which possesses a notch in which the lateral bases of the second valvifers articulate. Between each lateral swelling of the bulb on the dorsal side is a single short central arm, which makes a U-turn back on itself (fig. 3) and serves as an object of attachment for some of the large muscles operating the movements of the ovipositor. From the inside of each lateral swelling of the bulb of the second valvulae a fine ramus curves upward and caudad to attach along the dorsal margin of the corresponding second valvifer (fig. 3). Basal rami from both first valvulae also curve outward and then caudad alongside the rami of the two second valvulae, to make the same attachment.

When the insect is in the stinging or egg-laying position, the distal end of the rigid sting shaft is brought around into an almost anterior direction. The third valvulae bend readily at their connection with the second valvifers, so that the sting shaft is clasped between the third valvulae only at the very distal end of the latter. The first valvulae dart back and forth on their rails alternately and thus work their way through the body wall of the caterpillar host.

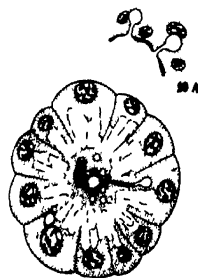
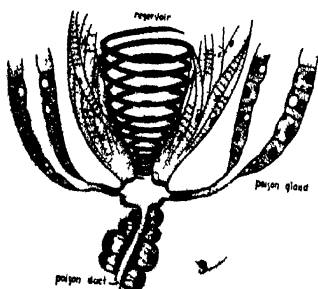
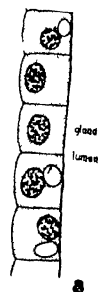
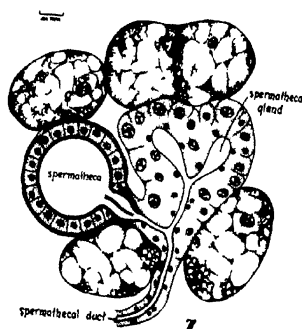
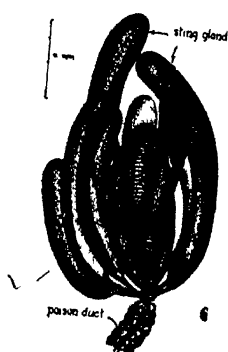
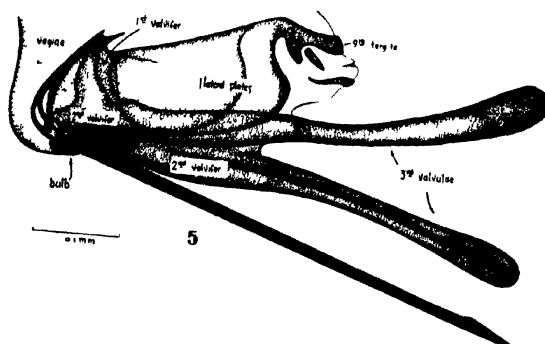
## INTERNAL STRUCTURES

*General Structure* (fig. 4).—In a mature female containing ripe eggs the ovaries occupy the main bulk of the abdomen. The two ovaries, each one consisting of two ovarioles, occupy lateral positions on either side of the mid-intestine. The developing eggs and their nurse cells may be seen along the course of the ovarioles, as well as mature ova that are stored in their sac-like posterior portions. Ventral to the mid-intestine the two parts of each ovary continue as right and left oviducts, respectively. These meet under the large posterior ganglion in a com-

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## EXPLANATION OF PLATE II

FIGURE 5. Ventro-lateral view of the ovipositor and associated parts. 6. Sting glands and reservoir. 7. Section through spermatheca, spermathecal glands, and surrounding bodies. 8. Section of wall of lubricating gland. 9. Longitudinal section of poison glands, and reservoir with muscular coat. 10. Cross-section through poison duct and poison duct cells.



mon oviduct continuous with the vagina, which immediately makes a turn back on itself. At the proximal end of the vagina is given off the duct to the spermatheca and spermathecal glands, minute bodies usually lying closely between the posterior ganglion and the vagina itself.

Distal to the opening of the spermathecal duct the vagina makes another turn to enfold the ventral and lateral aspects of the bulb of the second valvulae. Thus the eggs descending the genital passages are directed into the bulb of the sting shaft. At the inside of the neck of this last bend is given off the median unpaired lubricating gland, a fairly large, sometimes lobular gland, attached by a short stout neck, and lying flat in the body cavity between the two second valvifers.

Large poison glands (fig. 6) are found in the posterior part of the abdomen, laterally displaced either to the right or to the left of the hind-intestine, and usually extending close to the dorsal wall. This unit of glands is composed of sometimes eight, sometimes ten elongate lobes, surrounding a central poison reservoir, or pump, and attached by thin stalks to the base of the reservoir. The length of the glands varies from one-half to twice the length of the reservoir. From the base of the reservoir runs quite a long poison duct that is surrounded by numerous large poison duct cells. The poison duct courses ventrad, then cephalad along the lubricating gland and finally dips down over the central arm of the bulb of the second valvulae into the bulb itself.

*Spermatheca and Spermathecal Glands.*—A rather diagrammatic representation of this whole unit is shown in fig. 7. The spermatheca is a spherical cuticularized capsule, surrounded by a single layer of regular epidermal cells. A bulb-like process projects from the capsule and leads into a short, roughened duct. In one sectioned preparation an extremely fine duct was observed running through the center of this bulb, but its connection with the capsule proper was indistinct. The duct then branches into the spermathecal duct, and the spermathecal glands. The spermathecal duct follows a slightly convoluted course to the vagina and is invested with an irregular layer of cells. The ducts of the spermathecal gland are two blind extensions appearing like the stout ends of Indian clubs. They have extremely thin linings, appear water-clear in section, and are surrounded by lobes of rather irregular cellular layers. The lobes stain quite darkly, and in them are visible peripherally located nuclei. In addition to these nuclei there are a few somewhat smaller ones scattered more closely around the bulbs of the gland ducts. The whole mass is surrounded by a thin membranous coat that appears continuous around the spermathecal capsule. Around the capsule and glands and closely adhering to them are packed several other bodies. These bodies contain material that stains with Delafield's haematoxylin, and also large globules that stain with Sudan III. The bodies are therefore considered fat cells or clusters of fat cells. In serial sections the bodies are highly vacuolated, and nuclei, as shown with the Feulgen technique, are seen in some of them.

*Lubricating Gland.*—I have called this gland the lubricating gland because of the similarity it bears to glands at comparable locations in a number of ichneumonids described by Pampel (1913). In

*Habrobracon juglandis*, the wall of this gland is composed of a single layer of cuboidal cells with nuclei of varying sizes in varying positions. Rounded vacuoles of different sizes are present in some of the cells. The cytoplasm is homogeneous and fairly granular. There appears to be a slightly roughened lining to the lumen of the gland (fig. 8). Due to the position of the mouth of the gland on the vagina near the base of the ovipositor the secretion of the gland probably aids in the passage of the egg down through the poison canal of the valvulae.

*The Venom.*—The venom with which the insect paralyzes its host is secreted both by the large poison glands and by the poison duct cells. If the chemical nature of these venoms is comparable to those in other Hymenoptera (e. g., the honey bee), one of these groups is the acid glands, the other the alkaline glands.

*Poison Glands.*—Each poison gland (fig. 9) is made up of a single layer of heavy cuboidal cells, surrounding a central lumen. Nuclei are of two distinct sizes. The larger ones are round to oval, and peripherally placed in the cells. Some smaller nuclei are visible between the larger ones at the periphery, while there are many small nuclei that form more or less of a layer at the lumen ends of the cells. Some cells in section show distinct rounded vacuoles, the larger ones causing the inner surfaces of the cells to bulge out into the gland lumen. The cytoplasm appears homogeneous and finely granular. The stalk of each gland possesses a delicate spiral lining and leads into a cuticular bulb at the base of the reservoir. Apparently the secretion from the cells passes into the lumen, down the stalk into the bulb, and up into the reservoir.

*Reservoir.*—The reservoir, or pump (figs. 6, 9), appears as a quite ovate body, pointed at either end, and lined with a very heavy cuticular spiral, medium brown in color, presenting a very striking appearance. In the literature I have found only two other forms, *Bracon nigropedator* and *Aphidius* sp., both braconids, that possess this type of poison reservoir; both these forms were described by Berlese (1909).

The reservoir is surrounded by a heavy muscular coat, made up of numerous striated muscle fibers that run longitudinally and are attached at numerous points along the spiral lining. From this arrangement of muscular fibers, we may deduce the mode of action of this pump. Apparently when the longitudinal muscles contract, the spiral reservoir is compressed, like a mattress spring, thus ejecting the poison down through the poison duct. Consequently, when the muscle fibers relax and the spiral springs back into shape, it probably sucks a fresh supply of poison from the gland lumens back up into the reservoir.

*Poison Duct and Cells.*—From the small duct at the base of the reservoir runs the poison duct, surrounded by its numerous cells. The wall of the duct is rather heavily sclerotized and appears quite roughened in texture (fig. 10). The surrounding cells are heavily vacuolated and possess definite oval nuclei at the periphery of the cells. The vacuoles are sponge-like in appearance and occupy the larger part of each cell. As a result, the cytoplasm, which is finely granular, exists largely in the area around the nuclei.

From the poison duct arise numerous small spherical processes, connected to the duct itself by extremely fine necks (fig. 10A) and extending directly into the proximal portions of the surrounding cells. In sectioned material, these processes appear water-clear. It is undoubtedly directly through these very thin-walled processes—extensions of the poison duct—that the poison duct cells can pour their secretions and add to the venom from the poison glands. In addition to the regular nuclei of the large gland cells are numerous small nuclei close to the duct lumen, interspersed among and sometimes seen to hug the little processes. These minute processes are extremely numerous at the reservoir end of the duct, decrease in number along the duct's course, until none at all exist as the duct approaches and enters the bulb of the second valvulae. Moreover, as the duct curves around into the bulb, the poison duct cells disappear.

### DISCUSSION

The reproductive and associated organs of the honey bee have been the subject of the most careful investigations and are the best known of all the Hymenoptera (Bresslau, 1906; Adam, 1912; Snodgrass, 1925; v. Siebold, 1834; etc.). If we compare the organs of *Habrobracon* with those of the honey bee, certain striking similarities and differences are apparent.

In the honey bee there are numerous ovarioles composing the two large ovaries and possessing relatively small eggs, whereas in *Habrobracon* each ovary consists of but two ovarioles, each possessing a few relatively large eggs. Copulatory pouches, present in the honey bee, are absent in *Habrobracon*. A complicated muscular valve such as that which controls the dispersal of sperm from the spermatheca in the honey bee was not observed in *Habrobracon*. The bulb-like extension of the spermathecal capsule, however, suggests a valve.

In the honey bee there are two poison glands—the acid glands and the alkaline glands, both emptying separately into the bulb of the sting. The poison gland system of *Habrobracon* also has two distinct components: the poison glands themselves composed of 8 or 10 individual lobes surrounding the reservoir, and the poison duct cells that pour their secretions individually into the duct along its entire length.

Wilhelm Pampel has described the "Geschlechtsapparat" for many ichneumonids, and the main organs found in *Habrobracon* are present in one form or another among this group of Hymenoptera. The course which an egg must take in being laid by *Habrobracon*—that of being forced through the poison canal of the valvulae—is the same as that described by Pampel for the *Ophion*-like ichneumonids. The similarity between the poison reservoir in *Bracon nigropedator* and in *Aphidius* (as described by Berlese) and that in *Habrobracon* appear very close.

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GENERAL CATALOGUE OF THE HEMIPTERA, W. E. CHINA, General Editor, H. M. PARSHLEY, Managing Editor; Fascicle IV, FULGOROIDEA, PART 3, ARAEOPIDAE (DELPHACIDAE), by Z. P. METCALF, D.Sc., College of Agriculture and Engineering of the University of North Carolina. Published by SMITH COLLEGE, Northampton, Mass. 552 pp., \$5.00.

This volume by Professor Metcalf constitutes an important addition to the series of catalogues of Hemiptera and consists of a brief introduction with characters of the families, biographical, historical resumé, geographical distribution and form of present catalogue. It includes references to 137 genera and 1,114 species, in closely printed matter and shows evidence of very careful determination of synonymy, bibliographical references and distribution. While verification throughout is impossible for the reviewer, many entries that have been noted particularly are certainly correct. Dr. Metcalf is certainly to be congratulated on the completion of this notable piece of time-consuming and exacting work.

—H. OSBORN.

CLASSIFICATION OF THE DERMESTIDAE (LARDER, HIDE AND CARPET BEETLES) BASED ON LARVAL CHARACTERS, WITH A KEY TO THE NORTH AMERICAN GENERA, by BRYANT E. REES. U. S. Dept. of Agr. Miscellaneous Publication No. 511, 18 pp., 48 figs. 1943.

A paper based on material in the collection of the United States National Museum. Only very exactly identified larvae were used.—C. H. K.

THE ANOMALINI OF EASTERN NORTH AMERICA WITH DESCRIPTIONS OF THE LARVAE AND A KEY TO SPECIES (COLEOPTERA, SCARABAEIDAE), by P. O. RITCHER. Kentucky Agr. Exp. Station, University of Kentucky Bull. 442, 24 pp., 3 pls. (40 figs.). 1943.

A paper on larvae but which also gives good figures of the male genitalia of thirteen species the larvae of which are described and keyed out.—C. H. K.

**A SYNOPSIS OF THE LIMULODIDAE (COLEOPTERA):  
A NEW FAMILY PROPOSED FOR MYRMECOPHILES  
OF THE SUBFAMILIES LIMULODINAE (PTILIIDAE)  
AND CEPHALOPLECTINAE (STAPHYLINIDAE)**

CHARLES H. SEEVERS,  
Central YMCA College, Chicago, Illinois

AND

HENRY S. DYBAS,  
Field Museum of Natural History, Chicago, Illinois

The subfamily Cephaloplectinae of the Staphylinidae as now constituted is a very heterogenous group of genera; some of its members are not even staphylinids, and the others may well be assigned to other subfamilies. In 1883, Sharp described a very remarkable beetle, *Cephaloplectus godmani*, which had been collected from a Panamanian army-ant colony, and erroneously believing it to be a staphylinid, proposed the subfamily category to receive it. Subsequent investigators, especially Wasmann, perpetuated the error and increased the confusion immeasurably by assembling within the subfamily a number of unrelated beetles collected with army-ants and termites. The eight genera which have comprised the Cephaloplectinae resemble each other in only the most superficial characters and represent four rather widely divergent groups of beetles. One of these groups, including *Cephaloplectus* and related genera, should be removed from the Staphylinidae and the other groups should be reassigned to proper categories within that family. The investigations herein reported were initiated with the object of clearing up this situation as completely as possible with the material available. The problems proved to be more numerous than was first apparent, and instead of one paper, several will be necessary. The present paper is concerned with the removal of the non-staphylinid genera of the Cephaloplectinae and their combination with several genera of the Ptiliidae to form a new family. The remaining genera of the Cephaloplectinae will be reassigned in a later paper.

It has been evident to the writers from the inception of these studies that *Cephaloplectus* is closely related to the myrmecophilous genus *Limulodes* Matthews. This latter genus has from the time of its description in 1867 been classified with the Ptiliidae (= Trichopterygidae) to which it is undoubtedly related. The fact, however, that it occupies an isolated position with respect to that group was recognized by Ganglbauer (1899) who proposed the subfamily Limulodinae to indicate this. The writers have examined *Limulodes* and *Cephaloplectus* in detail, and believe that these two and a few related genera constitute a homogenous group which is sufficiently distinct from the Ptiliidae to be regarded as a separate family, the Limulodidae. In the morphological account which follows, it will be shown that these species are highly specialized for a myrmecophilous life and that the degree of specialization argues for long association with ants. The obligate myrmecophily resulting

from this association has served to bring about a distinctly isolated group; there are no known intermediate genera which would bridge the gap between the Limulodidae and the Ptiliidae. The contrast between *Cephaloplectus* (the most highly specialized of the group) and the Ptiliidae is particularly noteworthy.

The principal aim of this paper is, therefore, to present as complete an account of the morphology and taxonomy of the Limulodidae as is feasible with material available. The initial step in eliminating the confusion concerning the status of the Cephaloplectinae is thereby completed. The remaining genera of the Cephaloplectinae have been or will be discussed elsewhere by the writers: *Termitopsenius* Wasmann was referred to the Trichopseniinae and *Callopsenius* Wasmann to the Aleocharinae in a previous paper (Seevers, 1941), and *Vatesus* Sharp and *Wasmannotherium* Bernhauer (= *Xenocephalus* Wasmann) will be considered in a subsequent one. It is, of course, obvious that the subfamily name Cephaloplectinae is superfluous and ceases to exist as a category in the Staphylinidae. Since it seems desirable to summarize the history of the Cephaloplectinae, the writers have done so in a separate section of the paper, where all additions to the group and their dispositions are noted.

While all of the species herein incorporated within the family were not available for study, it is believed that sufficient material was at hand to permit the establishment of a useful basis for future studies. Of the twenty-seven species included in the family, the writers have examined fourteen, eight of which are new. Only one (*Paralimulodes* Bruch) of the five genera was not seen. Although many of the descriptions of the species not available appear inadequate for their recognition, host and locality data may make determinations possible.

All of the Limulodidae are myrmecophilous, and although they have been found with ants of the five major subfamilies, it appears as if they occur most abundantly with army ants of the genus *Eciton*. Many of them are probably monoxenous but this does not seem to be universally true, for the available data indicate the occurrence of some species with several hosts. More data may reveal, however, that what appears to be one species of beetle living with several different ants, may represent several closely related species of beetles, each associated with a different ant. There is some evidence at hand to support such a view, but no attempt to utilize these data is made at this time since they are scarcely numerous enough to be clearly significant. The ecological relationships of the group are discussed at greater length in another section of the paper (p. 561).

The family is now known to be distributed from Massachusetts to Argentina in the new world and to occur in the Australian continent. Judging only from one species, the Australian genus *Rodwayia* seems to be comprised of rather generalized forms which are quite closely related to several of the United States species. The most highly specialized members of the family, those of the genus *Cephaloplectus*, occur in the neotropics.

For aid in connection with these investigations, the writers are indebted to Dr. Orlando Park for many important specimens, to Dr. R. E. Blackwelder and Dr. W. M. Mann for co-operation in making the



material in the United States National Museum available for study, to Dr. P. J. Darlington for specimens from the Museum of Comparative Zoology, to Dr. C. H. Curran for the American Museum of Natural History material, and to Drs. Neal Weber, M. R. Smith, and Robert Gregg for identifications of host ants.

## HISTORICAL REVIEW OF THE SUBFAMILY CEPHALOPLECTINAE

As indicated in the introduction, it seems desirable to summarize the principal steps in the organization of the Cephaloplectinae and the reclassification of its genera as the subfamily is now dissolved. This should aid in preventing further confusion with respect to the group. The genera and species of the subfamily were catalogued by Eichelbaum (1909, p. 191), Bernhauer (1916, p. 443), and Scheerpeltz (1933, p. 1472).

1883. Sharp proposed the subfamily Cephaloplectinae to include the genus *Cephaloplectus* Sharp; one species, *C. godmani* Sharp, collected with army ants in Panama, was described.
1887. Wasmann proposed the subfamily Xenocephalini for the genus *Xenocephalus* Wasmann; one species, *X. clypeatus* Wasmann, collected with army ants in Brazil, was described.
1889. Wasmann included the genus *Vatesus* Sharp (1875) in the Xenocephalini; the one species, *V. latitans* Sharp, recorded from Brazil, had been classed with the Tachyporini.
1900. Wasmann regarded the name Xenocephalini as a synonym of Cephaloplectinae; this subfamily then included *Cephaloplectus*, *Xenocephalus*, *Vatesus* and a new genus *Exiloxenus* Wasmann. One species, *E. heyeri* Wasmann, collected with Brazilian army ants, was described.
1902. Wasmann assigned two new termitophilous genera, *Termitopsenius* Wasmann from Argentina and *Callopsenius* Wasmann (= *Eupsenius* Wasmann) from Paraguay, to the Cephaloplectinae.
1908. Wasmann referred *Exiloxenus heyeri* to the genus *Limulodes* Matthews (Trichopterygidae).
1921. Bernhauer (Deut. Ent. Zeit., 1921, p. 77) proposed the name *Wasmannotherium* for *Xenocephalus* (preoccupied, Kaup, Pisces, 1858).
1926. Mann included the genus *Eulimulodes* Mann in the Cephaloplectinae; one species, *E. mexicanus* Mann, collected with *Eciton* in Mexico, was described.
- 1890-1932. Eight additional species of *Cephaloplectus* were described or given names by Wasmann (1925), Mann (1926), and Bruch (1926); fifteen additional species of *Wasmannotherium* were described by Wasmann (1890, 1894, 1900, 1908, 1925, 1929), Bernhauer (1917), Mann (1925, 1926) and Bruch (1932).
1941. Seevers transferred *Termitopsenius* Wasmann to the subfamily Trichopseniinae, and *Callopsenius* Wasmann to the subfamily Aleocharinae.

In the present paper, *Cephaloplectus* and *Eulimulodes* are removed from the Staphylinidae and grouped with *Limulodes* and several other ptiliid genera in the newly proposed family Limulodidae. The two remaining genera of the Cephaloplectinae, *Wasmannotherium* and *Vatesus*, which should probably be classed as Tachyporinae, will be considered in another paper.

## LIMULODIDAE: MORPHOLOGICAL CONSIDERATIONS

*General Features.*—The habitus (figs. 1, 2, 4) of all of the limulodids is very similar and there is no difficulty in recognizing them. They are rather appropriately named, since their appearance is not unlike that

of a small horse-shoe crab. These beetles are apparently admirably adapted to withstand attack since they are compactly constructed and are equipped with many protective devices. Since they are all inhabitants of ant nests it is not unreasonable to suspect that these specializations protect them from their hosts to some degree or did so at an earlier stage in their evolution. It seems likely that the evolution of these characteristics was originally correlated with the evolution of myrmecophily, but there is reason to believe that the relationship between these beetles and their hosts has progressed to a point where protective devices are not so necessary. The observations of Park (1933), discussed in another section of the paper, indicate a more amicable relationship than is suggested by a review of the protective specializations. But whatever the actual situation may be, the series of protective modifications is very impressive, and few vulnerable areas are presented to the external environment. The most noteworthy of these adaptations are outlined in the following account:

(a) The wedge-shaped body is constructed with smooth, evenly round contours, the pronotum and elytra are broadly and strongly convex, and the abdomen is tapered. (b) The head is so deeply inserted in the prothorax that only a small area is presented anteriorly, and this surface, which is slightly convex, conforms to the broad arc formed by the pronotum apically. No openings are presented dorsally or anteriorly. (c) The antennae are partially or completely protected by withdrawal into deep fossae and by the presence of postgenal plates ventral to the antennal fossae. (d) The labrum, in repose, is contiguous with the anterior margin of the mentum, and covers the prementum, labial palpi, mandibles (in part), and the membranous parts (galea, lacinia) of the maxillae. (e) The overhanging pronotal and elytral margins protect the underparts. (f) The close relationship of prothorax and mesothorax virtually precludes movement between the two. This intimate association is brought about by the prolongation of the posterior pronotal angles to envelop the elytral humeri, which are ridged to interlock with the pronotal hypomera, by the carinate mesopleura which also interlock with the pronotal hypomera, and by the overlapping of the mesosternal carina by the large prosternal lobe. (g) The ankylosis of structures and the fusion of areas in the following situations: the inner elytral margins are interlocked so that their separation is difficult, the elytra are almost fused to the mesonotum, and the sternonotal, pleural and sterno-pleural sutures are absent. (h) The legs are afforded ample protection in various ways. The metathoracic legs are capable of complete retraction beneath huge metacoxal plates, and the tibia of the fore and middle legs may be partially withdrawn beneath laminations of the femora. The legs are frequently heavily armed. The side margins of pronotum and elytra aid in the protection of the legs. (i) The abdomen is capable of considerable retraction and may be drawn beneath the large elytra.

**Head Capsule and Tentorium.**—While the structure of the head is basically similar to that of the Ptiliidae, there are specializations, particularly in *Cephaloplectus*, that depart considerably from it. The head capsule and tentorium of *Limulodes* are figured by Stickney (1923, figs.

31, 177, 324, 469), in his comparative morphological study of the coleopterous head, to represent the Ptiliidae. Since the head structure of other Ptiliidae was neither figured nor discussed, the choice of a specialized beetle to represent the family was not well taken, even though the *Limulodes* head exhibits many characters in common with that of the ptiliids.

The head is inserted in the anterior foramen of the prothorax in such a manner that the "dorsum" of the head (vertex) is directed anteriorly. The "frontal" and "postclypeal" portions of the "dorsum" are deflexed and, because of the orientation of the head with respect to the thorax, occupy a ventral position. The terms vertex, front and postclypeus are used only relatively since the landmarks that determine these areas are absent or are of little value. The deflexed portion of the dorsum is not especially pronounced in *Limulodes* but is considerably so in *Cephaloplectus*, as the head seems to be somewhat inflated in that genus to extend for some distance cephalad.

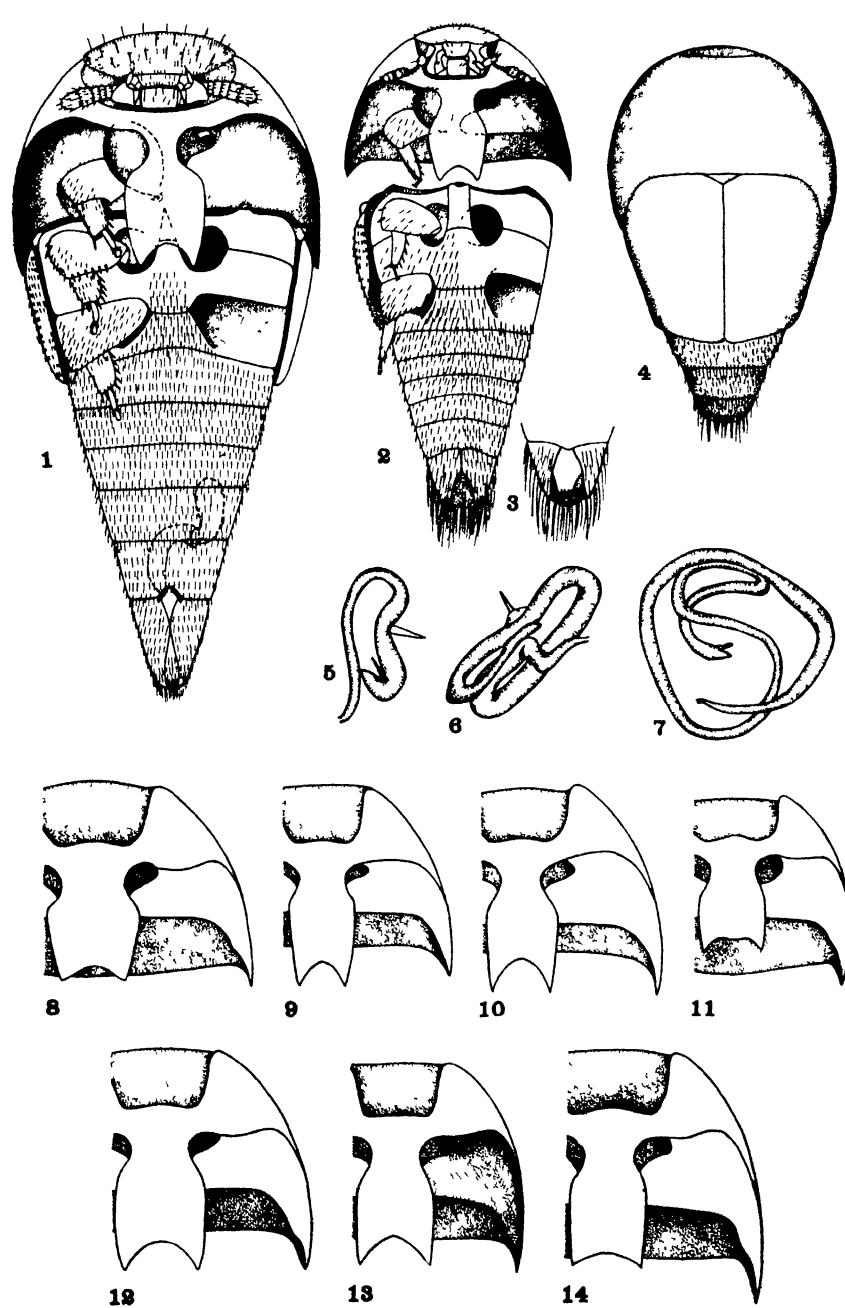
The antennal fossae vary considerably from a moderate size in *Limulodes* to profound cavities in *Cephaloplectus*. In the latter genus they are so deep as to be almost contiguous at the center of the head. The breadth of the head is variable, depending on whether the head capsule anterior and ventral to the antennal fossae is produced laterally into lamellae (*Cephaloplectus* and *Eulimulodes*), or not (*Limulodes*). All of the genera possess a shelf-like triangular plate ventral to the antennal fossae, probably formed from the postgenae.

The condition of the tentorium (figs. 15-18) is that of the Ptiliidae in general. The posterior tentorinae occupy positions at the posterior margin of the head capsule. This is presumably a rather generalized position as they have not migrated cephalad to give rise to a gula. The posterior tentorial arms extend forward to the juncture of the dorsal and anterior arms. The dorsal arms are well developed in all of the genera, but they terminate short of a connection with the vertex. The anterior arms are variable in length, depending upon the depth of the antennal fossae. In *Limulodes* (fig. 17) they are moderately long, but in *Cephaloplectus* (fig. 15) they are extremely short since the anterior tentorial pits are located deep within the antennal fossae. The posterior arms are connected caudally by a transverse tentorial bar.

The principal trends in the evolution of the limuloid head as shown by a comparison of *Limulodes* and *Cephaloplectus* seem to be: (1) a departure from the dorso-ventrally compressed head, so typical of the Coleoptera, and the dilation and deflexion of the dorsum so that the strongly convex vertex, front, and postclypeus occupy anterior and

#### EXPLANATION OF PLATE I

Figure 1. *Cephaloplectus mus* Mann. Ventral aspect. 2. *Limulodes paradoxus* Matth. Ventral aspect, male. 3. *Limulodes paradoxus* Matth. Ventral aspect of apex of abdomen, female. 4. *Limulodes parki* n. sp. Dorsal aspect. 5. *Limulodes paradoxus* Matth. Spermatheca. 6. *Limulodes stenotropis* n. sp. Spermatheca. 7. *Cephaloplectus mus* Mann. Spermatheca. 8. *Limulodes parki* n. sp. Prothorax. 9. *Limulodes navajo* n. sp. Prothorax. 10. *Limulodes pallidus* n. sp. Prothorax. 11. *Limulodes brachyscelis* n. sp. Prothorax. 13. *Limulodes stenotropis* n. sp. Prothorax. 14. *Limulodes philovagans* n. sp. Prothorax.



ventral positions in front of the labrum, and (2) the extreme development of the antennal fossae. While the structures of the dorsal surface seem to have become highly specialized, those of the ventral surface appear to have remained relatively conservative. Although derived of ptilioid stock, presumably at some rather remote period, the ventral side of the head and the tentorium have remained essentially the same.

*Antenna*.—Ten segments characteristically compose the antenna, but this number has been reduced to eight or nine segments (Bruch does not state exactly) in *Paralimulodes*. Two antennal forms are present in the group, those exemplified by *Limulodes* and *Cephaloplectus*. The first type is illustrated by figures 23–30. The club-shaped scape, which is of moderate length, is usually concealed within the antennal fossa. The second segment partially conceals the third segment which is set in its apex. Segments 3–7 are small and apparently do not vary greatly, while segments 8–10 are enlarged to form a loose club. The terminal three segments are somewhat variable and have some taxonomic value.

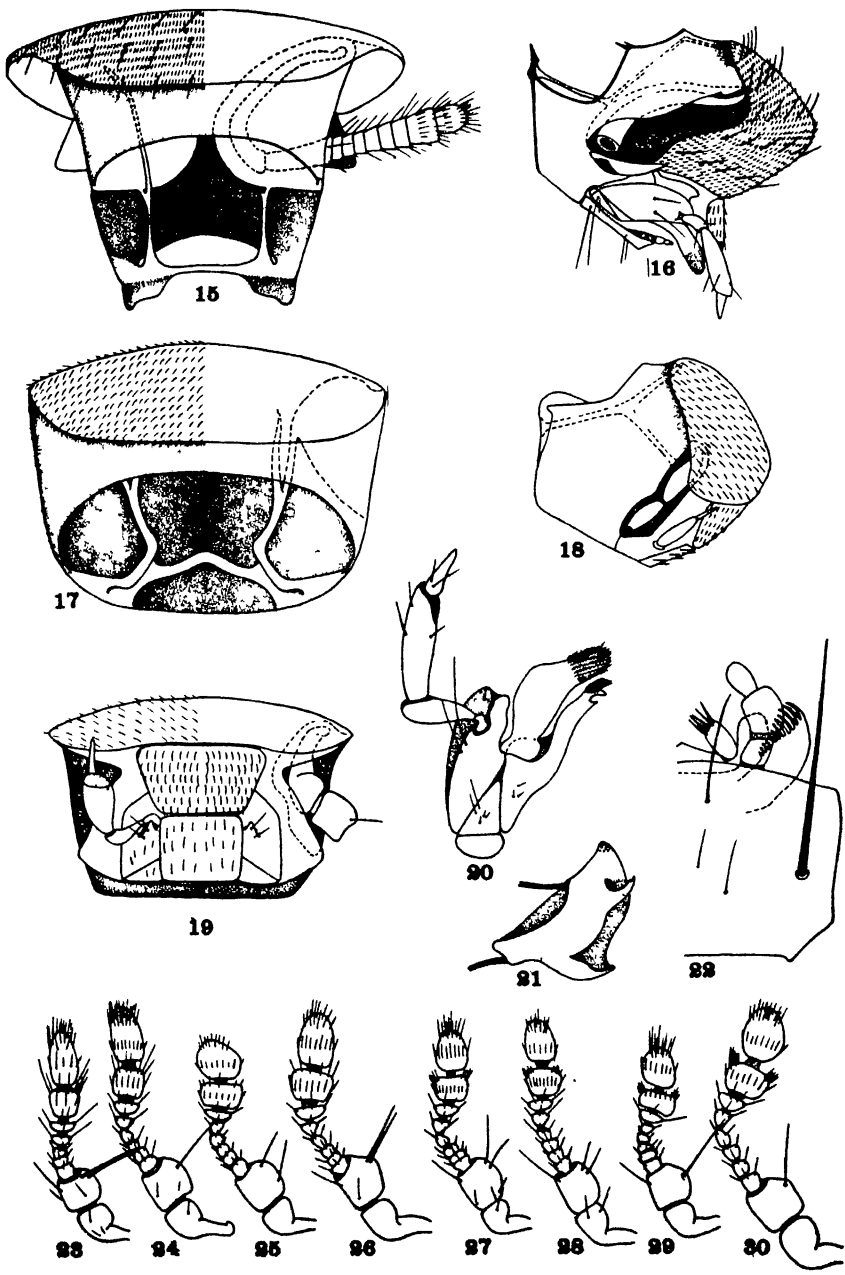
The *Cephaloplectus* antenna (fig. 15), which is deeply inserted in the head, is composed of an extremely long, arcuate, cylindrical scape, a very long second segment, six moderately large, transverse, intermediate segments, a large, rectangular penultimate segment, and a smaller, rounded terminal segment. Segments 3–10 are compressed.

*Eyes*.—The writers have been unable to detect eyes in any of the species examined and are inclined to regard eyelessness as a family characteristic despite the reports of their presence by some observers. Stickney (1923) indicates a rather large eye on his outline drawings of the *Limulodes* head but is inconsistent in its location in different views. While we do not know which North American species of *Limulodes* was studied by Stickney (since his designation *L. paradoxus* may have been incorrect), it is unlikely that he had a species unknown to us. There is certainly no eye of the proportions figured by Stickney in any of the species at hand so we are inclined to believe that he was mistaken. It is very likely that the large antennal fossa, which is outlined through the head capsule in slide preparations, was interpreted as an eye by Stickney for this error is an easy one to make. Other references to be questioned for the same reason include: Wasmann's description of a small eye in *Limulodes heyeri* and Bruch's reference to the single-faceted eyes of *Paralimulodes* and the large, flat eyes of *Limulodes argentinus*.

*Mouthparts*.—Because of the orientation of the head, the labrum is directed caudad in a horizontal plane and is so constructed that its apical

#### EXPLANATION OF PLATE II

Figure 15. *Cephaloplectus mus* Mann. Dorsal view of head. 16. *Cephaloplectus mus* Mann. Lateral view of head. 17. *Limulodes parki* n. sp. Dorsal view of head. 18. *Limulodes parki* n. sp. Lateral view of head. 19. *Limulodes parki* n. sp. Ventral view of head. 20. *Cephaloplectus mus* Mann. Maxilla. 21. *Cephaloplectus mus* Mann. Mandible. 22. *Cephaloplectus mus* Mann. Labium. 23. *Limulodes paradoxus* Matth. Antenna. 24. *Limulodes parki* n. sp. Antenna. 25. *Limulodes nevado* n. sp. Antenna. 26. *Limulodes pallidus* n. sp. Antenna. 27. *Limulodes stenocephalus* n. sp. Antenna. 28. *Limulodes manni* n. sp. Antenna. 29. *Limulodes brachyscolis* n. sp. Antenna. 30. *Limulodes philovagans* n. sp. Antenna.



margin closely approximates the cephalic margin of the mentum, and thus covers the mouth as well as the more delicate parts of the labium and maxillae. The only apparent modification within the group is in its proportions; it is, for example, considerably broader and more trapezoidal in *Cephaloplectus*.

The small mandibles (*Cephaloplectus*, fig. 21) are almost entirely concealed by the labium and maxillae. The medial margin of the mandible is straight and the molar surface is greatly reduced. The outer margin bears two large teeth; the basal tooth is broader and stouter than the subapical one which bears a denticle near its apex. The narrow, feebly rounded apex of the mandible is beset with a variable number of minute denticles.

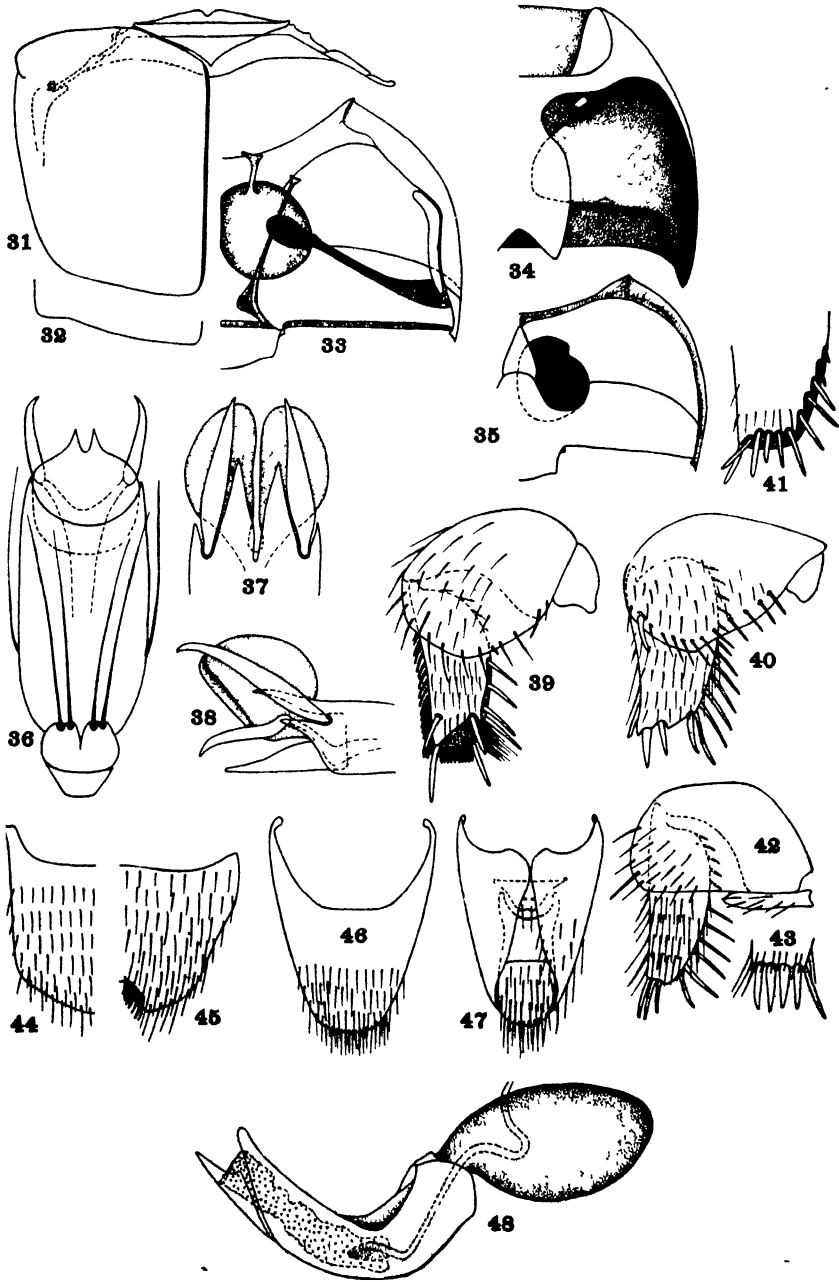
The maxilla of *Cephaloplectus* is illustrated by fig. 20. The galea is moderately broad and rather long and its rounded apex, which is directed medially, bears a series of longitudinal rows of short setae. The lacinia is shorter than the galea and more slender, and its incurved apex is incised to form a terminal tooth and a subapical one; it may or may not bear a terminal tuft of setae. The maxillary palpus articulates submarginally and subapically with the stipes. The four-segmented maxillary palpus consists of a small basal segment, moderately large intermediate segments and an acuminate terminal segment. The form of the second and third segments varies intergenerically.

The labium (*Cephaloplectus*, fig. 22) is composed of a large sclerite (probably the mentum) and the prementum. The parts of the prementum are difficult to interpret. In *Cephaloplectus* there is a median triangular membranous area (the glossae?), a lateral lobe (paraglossa?) on each side dorsal to the palpi, and a process, which bears terminal setae, articulating at the juncture of the above structures. Lateral and slightly dorsal to the paraglossa, there is a process bearing a medial row of spines; possibly this is the hypopharynx. The basal segment of the three-segmented labial palpus is cylindrical, the second segment broader and longer, and the third segment is more slender and somewhat ovoidal.

*Thorax*.—The pronotum, which is very similar in all of the genera, is strongly convex. The side margins converge strongly in front and form, with the front margin of the deeply inserted head, an evenly rounded anterior margin of the beetle. The posterior angles of the pronotum are prolonged and closely applied to the elytral humeri (figs. 1, 4). The

#### EXPLANATION OF PLATE III

Figure 31. *Cephaloplectus mus* Mann. Mesonotum and elytron. 32. *Cephaloplectus trilobitoides* Mann. Apex of elytron. 33–48. *Cephaloplectus mus* Mann. 33. Dorsal view of mesosternum, mesopleuron, metasternum, and metapleuron. 34. Prothorax, ventral view. 35. Ventral view of mesothorax and metathorax. 36. Ventral view of prothoracic tarsus. 37. Dorsal view of prothoracic tarsus (terminal segment). 38. Lateral view of prothoracic tarsus (terminal segment). 39. Prothoracic leg, anterior surface. 40. Mesothoracic leg, anterior surface. 41. Apex of mesothoracic tibia, posterior surface. 42. Metathoracic leg, anterior surface. 43. Apex of metathoracic tibia, posterior surface. 44. Eighth tergite, male. 45. Eighth sternite, male. 46. Ninth (?) abdominal segment, male, dorsal view. 47. Ninth (?) abdominal segment, male, ventral view. 48. Aedeagus.





inflexed portion of the pronotum (hypomeron) is very extensive. The hypomera (figs. 8-14, 34) are united to the prosternum (sterno-notal sutures absent) anterior to the coxae, while caudally they are strongly deflexed against the pronotum and extend medially almost to the mid-line. Along the free caudal margin of each hypomeron there are two grooves into which mesothoracic carinae interlock; the medial one receives a carina of the mesopleuron, and the lateral one the elytral humeri.

The prosternum consists of a transverse bar in front of the coxae and a large prosternal lobe. The latter is narrow between the coxae and then expands to form a large plate which covers the mesosternum and a portion of the metasternum. The apex of the prosternal lobe is emarginate. The prothorax of the Limulodidae is somewhat specialized, yet during the speciation within the family it has remained remarkably uniform in structure. The very conspicuous changes which marked the evolution of the *Cephaloplectus* head were not accompanied by important modifications of the thorax.

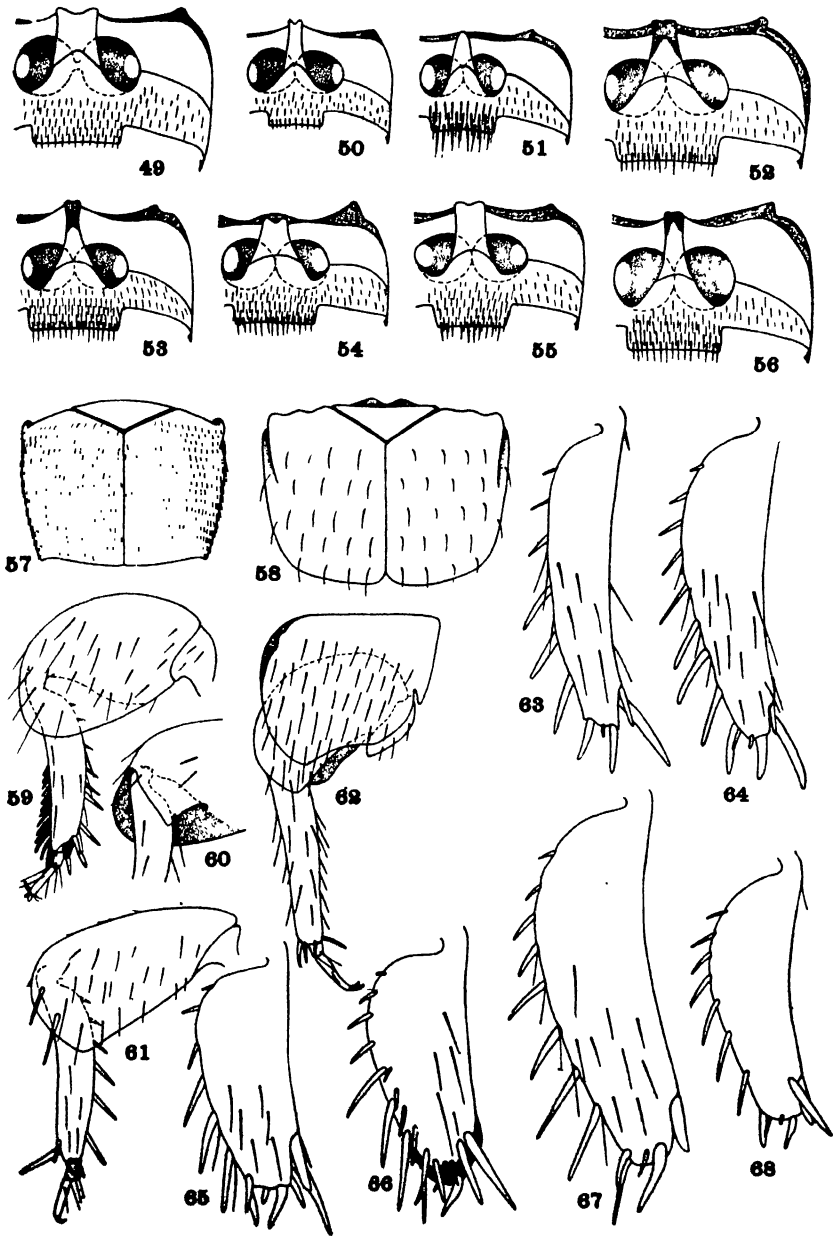
The sternal and pleural regions of the mesothorax are not clearly differentiated. The lateral limit of the mesosternum (figs. 35, 49-56) is not demarcated since the sterno-pleural sutures usually separating it from the mesepisterna are absent. In addition, the pleural region is not divided by the pleural sutures into an episternum and epimeron and so will be referred to as the mesopleuron. The mesosternum is more or less elevated medially to form a carina of variable proportions; this is in some instances slightly produced apically. The mesopleuron is sharply margined at the anterior and lateral borders of the ventral surface since it is bent abruptly dorsad to form the anterior and lateral faces of the mesothorax. The mesopleuron is also carried on to the dorsal surface to some extent. The anterior face of the mesopleuron bears a vertical carina which interlocks with the pronotal hypomeron.

The mesocoxal cavities are enclosed internally by large capsules (figs. 33, 35) formed apparently in part by the mesosternum and in part by the metasternum; the contribution of each is difficult to determine. The mesocoxal capsules are contiguous in some instances and are somewhat separated in others.

The metasternum extends forward between the coxae on the ventral surface to meet the mesosternum. Caudally the metasternum is produced between the hind coxae to form a rather broad process which to a slight degree overlies the third abdominal sternite. The metasternum is

#### EXPLANATION OF PLATE IV

Figure 49. *Limulodes parki* n. sp. Ventral view of mesothorax and metathorax. 50. *Limulodes navajo* n. sp. Same. 51. *Limulodes pallidus* n. sp. Same. 52. *Limulodes bolivianus* n. sp. Same. 53. *Limulodes stenotropis* n. sp. Same. 54. *Limulodes brachyscelis* n. sp. Same. 55. *Limulodes philovagans* n. sp. Same. 56. *Limulodes manni* n. sp. Same. 57. *Limulodes navajo* n. sp. Elytra, scutellum. 58. *Limulodes pallidus* n. sp. Same. 59-63. *Limulodes paradoxus* Matth. 59. Prothoracic leg, anterior surface. 60. Prothoracic femur and tibia, posterior surface. 61. Mesothoracic leg, anterior surface. 62. Mesothoracic leg, posterior surface. 63. Mesothoracic tibia. 64. *Limulodes parki* n. sp. Mesothoracic tibia. 65. *Limulodes brachyscelis* n. sp. Mesothoracic tibia, anterior surface. 66. Same, posterior surface. 67. *Limulodes philovagans* n. sp. Mesothoracic tibia, anterior surface. 68. *Limulodes navajo* n. sp. Same.



separated from the mesopleuron lateral to the middle coxae by a suture which extends from the coxal cavity to the lateral margin.

The divisions of the mesonotum ("scutellum") are not easy to determine and no attempt will be made to distinguish prescutum, scutum and scutellum. In addition to the raised triangular area visible externally, there are rather extensive lateral processes (fig. 31) which taper to slender arms for some distance beneath the elytra and articulate with them.

The elytra are intimately articulated with the mesonotum and are in most instances difficult to separate from it. The elytron articulates with a small condyle of the mesonotum near the elytral base and with a knob at the apex of the lateral arm of the mesonotum which fits in an acetabulum on the ventral face of the elytron medial to the humerus. The elytron also bears a small condyle near its inner basal angles which articulates with the mesonotum. The elytra are incapable of being moved and the articulating surfaces mentioned approach ankylosis in many instances. Furthermore, the elytra are intergrooved along the median line to prevent movement. The elytral humeri are produced as short carinae (figs. 1, 2, 57) which interlock with the pronotal hypomera; the carinae are transversely striated in some instances. The elytral epipleurae are moderately large and are almost appressed against the elytra.

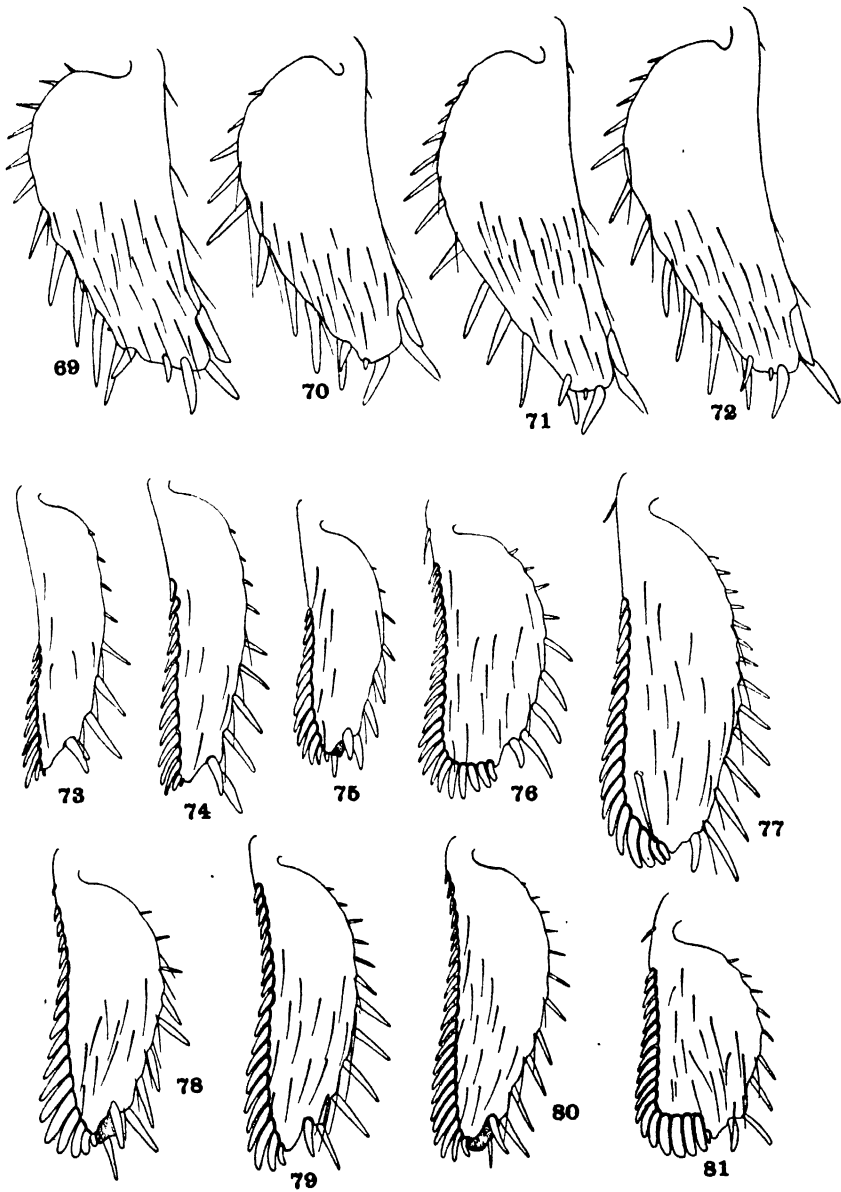
The metapleural elements (fig. 33) are apparently represented by a short metepisternum, which gives rise at its caudal end to the condyles for the lateral articulation of the hind coxa, and a metepimeron. The metepimeron (figs. 31, 33) is closely associated at its anterior end with the lateral arm of the mesonotum mentioned above, in fact, it is so closely applied to the mesonotum that it is invariably removed with the elytra and mesonotum when they are dissected from the body. The position of the metepimeron in these cases is such as to mislead one into interpreting it as a vestige of a wing, unless care is taken in noting its relationships.

The writers have been unable to detect any structures which may be interpreted as metanotum or any vestiges of wings. The absence of wings and the non-sclerotized metanotum are apparently the result of long association with ants. There are references in literature to the existence of vestigial wings in *Limulodes* but we are of the opinion that these have resulted from misinterpretation of the metepimeron.

*The Legs.*—The legs seem to be the most variable structures of the body and offer the best taxonomic characters. The following generalizations are supplemented by detailed considerations in connection with species diagnoses.

#### EXPLANATION OF PLATE V

Figure 69. *Limulodes pallidus* n. sp. Mesothoracic tibia, anterior surface. 70. *Limulodes stenotropis* n. sp. Same. 71. *Limulodes manni* n. sp. Same. 72. *Limulodes bolivianus* n. sp. Same. 73. *Limulodes paradoxus* Matth. Prothoracic tibia, anterior surface. 74. *Limulodes parki* n. sp. Same. 75. *Limulodes navajo* n. sp. Same. 76. *Limulodes pallidus* n. sp. Same. 77. *Limulodes philovagans* n. sp. Same. 78. *Limulodes stenotropis* n. sp. Same. 79. *Limulodes manni* n. sp. Same. 80. *Limulodes bolivianus* n. sp. Same. 81. *Limulodes brachyscelis* n. sp. Same.



The anterior coxae (figs. 1, 2) are large and ovoidal; anteriorly they articulate with moderately long, rod-like trochantins which extend into the coxal cavity from beneath the hypomera; caudally each coxa is drawn out into a short process which rotates in an acetabulum on the dorsal surface of the prosternal lobe.

The globose mesothoracic coxae (figs. 1, 2) are set in coxal capsules which possess lateral foramina for the coxal articulation with the coxal process of an apophysis (fig. 33) near the posterior border of the mesopleuron.

The metathoracic coxae (figs. 1, 2, 62) are very large and platelike; they articulate medially with a metasternal condyle and laterally with a process of the metepisternum. The coxa completely conceals the hind femur and the entire metathoracic leg may be retracted beneath it.

The femora (figs. 39-42, 59-62) are usually broad and compressed and are expanded apically into laminae to partly conceal the tibiae; they may be bilaminar or unilaminar. The femora are frequently armed with spines and setae. The tibiae are also compressed; they are variable in shape and offer good taxonomic characters. The tibiae are usually heavily armed with spines, but *Paralimulodes* possesses spineless tibiae and *Rodwayia* seems to have but few. The prothoracic tibiae characteristically bear combs of spines along the lateral and apical borders. The anterior tibiae of the males have a dense tuft of hairs on the medial border near the apex.

The tarsi are composed of three tarsomeres; the basal segment is extremely small and is set deeply within the apex of the tibia; the second segment is also rather small but is clearly visible, and the third segment is usually quite long. All previous descriptions of the *Limulodes* tarsus have stated that they are two-segmented but in view of the minuteness and position of the basal segment, this is easily understandable.

The tarsus of *Cephaloplectus* (fig. 36-38) is somewhat more specialized than that of the other genera. The second segment is incised medially and appears bilobed; each lobe bears two very long and stout setae which extend along the plantar surface almost to the apex of the terminal segment. The third segment is elongated and bears a rather complex pretarsus. The apex of the upper surface (fig. 37) of the third segment is deeply incised medially to form two strong triangular processes. The ungues of the pretarsus articulate with the dorsal surface lateral to these processes. The side of the terminal segment (fig. 38) is drawn out into a spine ventral to the ungues. In addition to the ungues mentioned above, the pretarsus consists of a ventral unguitractor plate (fig. 36), a lateral pair of ventrally directed claw-like processes, and a pair of large, somewhat membranous, lamellae. The unguitractor plate, which is set in the end of the tarsus ventrally, is incised at the apex. The large leaf-like lobes are probably derivatives of the arolium but the origin of the lateral claws is somewhat difficult to determine. The tendon of the retractor muscles which extends to the pretarsus inserts, apparently, on the unguitractor plate, and then divides to extend on to the lateral claws upon which it also inserts.

**Abdomen and Genitalia.**—The abdomen, which is very contractile, tapers strongly to a narrow, rounded apex. The venter is rather convex; the dorsum is less so. The first two tergites are present beneath the elytra; the first is very feebly sclerotized. The sternites and tergites of segments 3–7 are generalized in structure, with the exception of the third sternite (figs. 1, 2) which is deeply depressed on each side to receive the metathoracic legs. Segments 3–7 bear a single paratergite on each side; these sclerites overlap the tergites somewhat. The eighth sternite and tergite are longer than the previous ones; the eighth male sternite may be incised medially and in some species of *Cephaloplectus* this incision may be bordered by combs of spines (fig. 45).

The sclerites of the ninth and tenth segments, which are difficult to homologize, are as follows: the apparent ninth tergite (figs. 46, 47) forms a tubular structure as its sides are extended ventrad and then mesad to the mid-line. Within this tubular sclerite on the ventral side, there is one sclerite in *Limulodes* and two in *Cephaloplectus* (fig. 47). The smaller, triangular, proximal sclerite in the male of *Cephaloplectus* is almost concealed within the tube while the larger, distal one, with its broadly rounded apex, protrudes from the tube ventrally. In the female of *Cephaloplectus*, these two sclerites are subequal in length.

The aedeagus of the male, as seen in *Cephaloplectus*, consists of a large proximal sac (fig. 48), which is very feebly sclerotized, and a distal, strongly sclerotized tube. The distal tube, which is sharply curved near the middle, seems to consist of one piece except for a separate flap-like apical sclerite which is hinged by a membranous area to the body of the tube. The ejaculatory duct enters the basal bulb, passes into the tube and terminates in an intromittent organ, the structure of which was not determined. This intromittent organ rests at the base of an extensive eversible sac which is beset throughout with minute denticles.

The spermatheca of *Limulodes paradoxus* is a slender U-shaped tube as illustrated by figure 5. Modification of this tube within the family is manifested by more extensive coiling; an intermediate condition is illustrated by *Limulodes stenotropis* (fig. 6) and the extreme situation by *Cephaloplectus* (fig. 7). Each of these spermathecae bears a lateral, appendiculiform process; this is probably a glandular sac.

## ECOLOGICAL CONSIDERATIONS

The only recorded observations concerning the behavior of *Limulodes* are those of Park (1933) who studied the activities of *parki* n. sp. (then identified as *paradoxus* Matthews) in laboratory colonies of *Aphaenogaster fulva aquia* Emery. The most noteworthy observations made at that time are summarized briefly in the following account.

*Limulodes* was observed most frequently in the immediate vicinity of the host brood; some individuals were on the larvae when the colony was exposed in the field, and most of them constantly attended the larvae in the laboratory. They were noted to walk or run rapidly about among the ants, to cling to the larvae and pupae even when they were transported by the workers, and to ride the ants themselves. The riding of the workers by these beetles was noted on a number of occasions,

particularly when the larvae and pupae were removed from the observation colony. This riding was accompanied by feeding on the part of the beetles in many cases. The food of the beetles was obtained by scraping oils and other materials from the integument of the larvae, pupae and even the workers. In doing so, the beetles were engaged in the same way as the ants themselves, for they are constantly licking and scraping the brood and one another. Thus the beetles apparently take advantage of the exudations which form an essential part in the maintenance of the social organization. Park described the feeding behavior in some detail, noting the use of the setose galeae as excellently adapted combs for brushing integumental exudates from the hosts, and the laciniae and mandibles as aids in conveying materials to the mouth. He accredits the greatest role in feeding to the mandibles. The reaction on the part of the ants to the presence of the beetles was one of almost complete indifference, and only on a few occasions were the ants observed to attempt to dislodge beetles from their bodies or, in one case, to attempt to bite a beetle. Park concluded his studies with the belief that *Limulodes* is an obligatory synoekete which feeds on exudations of the host, and is not carnivorous nor a scavenger on nest refuse.

It will be noted from the list of records concluding this section of the paper that thirteen genera of ants are known to act as hosts to these beetles. These genera represent widely different groups of ants since the five principal subfamilies of ants are included. It is probably significant that the more generalized members of the Limulodidae occur with the greatest number of ant genera. As a matter of fact, only a relatively few species of the family occur with other than army ants; these are all members of *Limulodes* and *Rodwayia*. The family seems to have reached its greatest development in the American tropics where the more specialized members are all guests of *Eciton*.

Although the data pertaining to host relationships are inadequate, it seems that some of the species of beetles may occur regularly with several hosts (polyxenous) while others are apparently monoxenous. In no instance are the records sufficient in number to prove conclusive. Seven species have been recorded with more than one ant: four with two species of ants (of the same genus) and three with more than two species of ants (of several genera). There is evidence at hand to indicate that what we now regard as one species of *Limulodes* may prove to be more than one, so that some of these species are probably monoxenous. This is particularly true of *L. paradoxus*, in which case populations from different host species differ in characters which will probably serve to distinguish them as species. We refrain from making these specific distinctions at the present time since our data are scarcely large enough to carry sufficient weight. *L. parki* n. sp., as now defined, may also prove to be a complex of species, but this decision must also await more material. In this situation, however, the populations are exceedingly close, and it is rather interesting that such closely allied forms occur with four genera of ants, *Aphaenogaster*, *Formica*, *Pheidole*, and *Leptothorax*.

## HOST RECORDS

Genus *Lasius* (Formicinae)

- L. umbratus mixtus* var.  
*aphidicola* Walsh..... *Limulodes paradoxus* Matth.—U. S.  
*L. (Acanthomyops) claviger* Rog... *Limulodes paradoxus* Matth.—U. S.

Genus *Formica* (Formicinae)

- F. rufibarbis* var. *gnava* Buck..... *Limulodes parki* n. sp.—U. S.  
*F. sp., rufa* group..... *Limulodes parki* n. sp.—U. S.

Genus *Aphaenogaster* (Myrmicinae)

- A. fulva aquia* Buckley..... *Limulodes parki* n. sp.—U. S.

Genus *Pheidole* (Myrmicinae)

- P. dentata* Mayr..... *Limulodes parki* n. sp.—U. S.  
*P. triconstricta* var.  
*ambulans* Emery..... *Limulodes argentinus* Bruch—Argentina.

Genus *Leptothorax* (Myrmicinae)

- L. curvispinosus* Mayr..... *Limulodes parki* n. sp.—U. S.

Genus *Acromyrmex* (Myrmicinae, tribe Attini)

- A. lundii* Guérin..... *Limulodes elongatus* Bruch—Argentina.  
*A. (Moellerius) heyeri* Forel..... *Limulodes elongatus* Bruch—Argentina.

Genus *Eciton* (Dorylinae)

- E. (E.) burchelli* Westwood..... *Limulodes brachyscelis* n. sp.—Panama.  
*Cephaloplectus mus* Mann—Panama.  
*E. (E.) vagans* Olivier..... *Limulodes philovagans* n. sp.—Ecuador.  
*Cephaloplectus mus* Mann—Ecuador.  
*E. (Labidus) coecum* Latreille.... *Limulodes bolivianus* n. sp.—Bolivia.  
*Limulodes heyeri* Wasmann—Brazil.  
*Cephaloplectus trilobitoides* Mann—Guatemala.  
*E. (Labidus) praedator* F. Smith.. *Cephaloplectus flavus* Mann—Costa Rica.  
*E. (Acamatus) hetschkoi* Mayr.... *Cephaloplectus argentinus* Bruch—Argentina.  
*E. dulcius jujuyense*..... *Cephaloplectus argentinus* Bruch—Argentina.  
*Limulodes tibialis* Bruch—Argentina.  
*E. (Acamatus) spegazzinii* Emery. *Paralimulodes wasmanni* Bruch—Argentina.  
*E. (Neivamyrmex) wheeleri*  
Emery..... *Eulimulodes mexicanus* Mann—Mexico.  
*E. (Acamatus) sp*..... *Limulodes pallidus* n. sp.—Mexico.  
*E. sp*..... *Cephaloplectus godmani* Sharp—Panama.

Genus *Cheliomyrmex* (Dorylinae)

- C. nortoni* Mayr..... *Limulodes mexicanus* Silvestri—Mexico.

Genus *Camponotus* (Formicinae)

- C. nigriceps*..... *Rodwayia orientalis* Lea—Australia.  
*C. aeneopilosus*..... *Rodwayia orientalis* Lea—Australia.  
*C. novae-hollandiae*..... *Rodwayia orientalis* Lea—Australia.

Genus *Polyrhachis* (Formicinae)

- P. ammon*..... *Rodwayia orientalis* Lea—Australia.  
*P. sp*..... *Rodwayia minuta* Lea—Australia.

Genus *Iridiomyrmex* (Dolichoderinae)

- I. sp*..... *Rodwayia orientalis* Lea—Australia.  
*I. sp*..... *Rodwayia minuta* Lea—Australia.

Genus *Ectatomma* (Ponerinae)

- E. metallicum*..... *Rodwayia orientalis* Lea—Australia.  
*Rodwayia minuta* Lea—Australia.

Genus *Amblyopone* (or near thereto) (Ponerinae)

- A. sp*..... *Rodwayia intercoxalis* Lea.

## Genus unknown

- Limulodes navajo* n. sp.—U. S.  
*Limulodes stenotropis* n. sp.—Costa Rica.  
*Limulodes manni* n. sp.—Costa Rica.



## ORDER COLEOPTERA

## LIMULODIDAE NEW FAMILY

**Limulodinae**: subfamily of Trichopterygidae, Ganglbauer, 1899, *Käfer v. Mitteleuropa* 3, p. 297.

**Limulodinae**, Csiki, 1911, *Coleopt. cat.* 32, p. 55 (catalogue).

**Cephaloplectinae** (in part): subfamily of Staphylinidae, Sharp, 1883, *Biol. Cent. Amer.* 1 (2), p. 295.

Small, myrmecophilous beetles possessing a limuloid form; broadly rounded anteriorly, broadest near base of pronotum, abdomen tapered. Head deeply inserted in the prothorax, scarcely visible from above, conforming to the rounded contour of pronotum. Brachelytrous and apterous.

Head capsule so modified that definite sclerites are not distinguishable; head capsule strongly inflated anterior to the labrum in some genera. Labrum, in repose, directed caudad, almost horizontal in position and contiguous with mentum, thus covering and protecting many of the mouthparts.

Antennae ten-segmented (except in *Paralimulodes*), inserted in antennal fossae which may be extremely cavernous in some genera. Two general antennal forms are typified by *Limulodes* (figs. 23-30) and *Cephaloplectus* (fig. 15).

Gula absent, the postgenae united caudal to the mentum. Postgenae produced to form a shelf-like plate ventral to the antennal fossae. Tentorium composed of two long posterior arms connected by a transverse bar at the level of the posterior tentorial pits, two short anterior arms (extremely short in *Cephaloplectus*), and two rather long dorsal arms.

Eyes absent in all species observed; reports of eyes by some investigators have never been authenticated.

Mandibles very small, molar surface greatly reduced, outer margin bearing several teeth. Labium comprised of a rectangular mentum and a membranous prementum bearing a three-segmented palpus.

Maxilla composed of the lobose galea which bears rows of short setae and the slender lacinia with its toothed apex. The four-segmented maxillary palpus articulates sub-apically with the stipes.

Pronotum strongly convex, overlapping the base of the elytra, its produced posterior angles interlocking with the elytral humeri. Prosternum comprised of a transverse bar anterior to coxae and a large prosternal lobe which is directed caudally to overlie the mesosternum. Sterno-notal suture absent, the prosternum united to pronotal hypomera in front of coxae. The lateral and dorsal sides of the prothoracic coxal cavities formed by extensive hypomera. Anterior coxae ovoidal, posteriorly produced into a nipple which rotates in an acetabulum on the dorsal face of the prosternal lobe.

Mesosternum elevated at middle into a carina of variable form. Mesosternum and mesopleuron fused (sterno-pleural suture absent), mesopleuron not separable into mesepisternum and mesepimeron (pleural suture absent). Mesopleuron carinated to interlock with pronotal hypomeron. Mesothoracic coxae set in coxal capsules derived from both mesosternum and metasternum.

Mesothoracic scutellum produced laterally as long arms which articulate with acetabula on the ventral surfaces of the elytra. Elytra short, interlocked at median line and almost ankylosed with scutellum; epipleurae moderately large.

Wings absent and the metanotum entirely unsclerotized; no vestiges of these structures could be noted in any instance.

Metasternum produced and elevated between the middle coxae to meet the mesosternum and posteriorly between the hind coxae. Metepimeron articulating with the lateral arm of the mesonotal scutellum. Metepisternum short, slender. Metathoracic coxae large and platelike, almost concealing the metathoracic legs.

Femora compressed, laminated distally to partially cover tibiae. Tibiae compressed, subject to considerable variation in size and form, the front and middle tibiae usually rather heavily armed. Tarsi three-segmented; basal segment extremely small and concealed within the apex of the tibia. Pretarsus rather specialized in some genera.

Abdomen tapering to narrow apex, quite contractile. Sternite of the third segment deeply depressed laterally to receive the legs. Segments 3-7 with one paratergite on each side. Eighth sternite subject to modification in the male. Ninth tergite (?) produced ventrad to form a cylindrical tube (open on the ventral side) about the terminal part of the abdomen; within this tube are one or two ventral sclerites. Aedeagus comprised of a proximal bulbous portion and a more slender tubular distal part. Spermatheca tubular, varying from a simple U-shape to a much coiled form, and possessing a small tubular evagination at a variable distance from the apex.

*Type Genus of the Family.*—*Limulodes* Matthews.

*Comparison of Limulodidae and Ptiliidae.*—There is no doubt of the ptiliid affinities of the beetles under consideration. One needs to do no more than compare the structure of the head capsule and mouthparts in order to have the relationship clearly established. But in spite of this basic similarity, it is evident after detailed study that the limulodids have been isolated for a long period of time, and that they have become quite specialized for a myrmecophilous life. This long isolation has resulted in the assemblage of a complex of characters that distinctly differentiates this group from any of the ptiliids. It is this pronounced evolutionary trend away from the ptiliids that justifies, in our opinion, the separation of the group as a family.

The following limulodid characteristics are seldom or never encountered among the Ptiliidae: the large prosternal lobe, ten-segmented antennae, voluminous antennal fossae; eyelessness, aptery, the non-sclerotized metanotum, mesonotal arms articulating with the elytra, interlocking of elytral humeri and pronotum, spermathecal form, distinctive terminal abdominal segments, habitus and specializations for protection, obligate myrmecophily. It is obvious, of course, that some of these characters may appear from time to time among the ptiliids, but nowhere in that group do we find species that resemble the limulodids in having this set of characteristics. It is the entire complex of characters to which we direct attention, and these sharply demarcate the Limulodidae.

The conspicuous prosternal lobe is the most distinctive single characteristic of the family. None of the Ptiliidae possesses a prosternal lobe at all similar to it. Within the Limulodidae the lobe has been remarkably constant, for even *Cephaloplectus*, which has deviated considerably from *Limulodes* in some respects, shows no appreciable modification of this character.

The ten-segmented antennae differ from the typical ptiliid antennae not only in the reduced number of segments but also in general structure. However, the ptiliid antennae are somewhat variable in structure, so it is questionable to what extent a comparison may be made in this respect. The compressed antennae of *Limulodes*, and especially those of *Cephaloplectus*, are departures from the verticillate type so commonly noted among ptiliids.

The suggestion of antennal fossae may be noted in some ptiliids, but it is, indeed, only slightly suggestive of those encountered in this group. Among the Limulodidae, there is a progressive increase in the size of the fossae until in *Cephaloplectus* a situation is presented which is scarcely paralleled among the beetles; the head is so deeply impressed that the antennal fossae virtually meet in the center of the head.

The loss of eyes and wings is undoubtedly an accompaniment of the specialized mode of life of these beetles. Degenerative evolution is rather commonly noted in many groups of specialized insects and there are blind and wingless members of many families of beetles. In the Limulodidae, these losses apparently occurred early in the evolution of the group and they have become family characteristics. It appears that the evolution of aptery occurred early, since accompanying this change there has been the loss of the metanotal elements, and the locking of the elytra by the base and posterior angles of the pronotum.

The habitus of these beetles is of minor importance in distinguishing them from the Ptiliidae, but is, nevertheless, distinctive. The same may be said for a series of minor modifications which seem to have had adaptive significance in connection with myrmecophily. The sum total of these "protective" devices is quite impressive and distinctive; they are discussed in the morphological section of the paper.

The fact that the Limulodidae are obligate myrmecophiles is important in contrasting them with the Ptiliidae, for the members of the latter group are primarily fungus-spore feeders. Obligate myrmecophily occurs in some genera of the Ptiliidae without being characteristic of any natural group within the family, and apparently without inducing the extreme deviations from the general ptiliid structure.

#### KEY TO THE GENERA AND MANY OF THE SPECIES OF LIMULODIDAE

1. Antennae with fewer than ten segments (p. 578) . . . . . Genus **Paralimulodes**
- Antennae ten-segmented . . . . . 2
2. Antennal scape very long; segments 3-9 of antennae gradually incrassate, antennae not clubbed (p. 579) . . . . . Genus **Cephaloplectus** . . . 3
- Antennal scape moderately long, antennal segments 3-7 small, segments 8-10 forming a loose club . . . . . 5
3. Apical margins of elytra sinuate (fig. 32), (p. 583) . . . . . **C. trilobitoides**
- Apical margins of elytra not sinuate . . . . . 4
4. Marginal row of spines of the prothoracic tibiae numbering about 42, (p. 582) . . . . . **C. flavus**

- Marginal row of spines of the prothoracic tibiae numbering typically 33-35 (small form, 28-32), (p. 581)..... **C. mus**
5. Pronotal hypomera (anterior to the prothoracic coxae) convex medial to the pronotal margin (p. 584)..... Genus **Eulimulodes**
- Pronotal hypomera concave medial to the pronotal margin..... 6
6. Prothoracic tibiae with a row of spines on the outer margins (p. 567), Genus **Limulodes**..... 7
- Prothoracic tibiae without a row of spines on the outer margin (p. 578), Genus **Rodwayia**
7. Dorsal surface with rows of long, erect setae in addition to pubescence (p. 573)..... Subgenus **Cephaloplectodes**
- Dorsal surface with fine, short, recumbent pubescence only..... 8
8. Elytral apices sinuate (fig. 57), (p. 572)..... Subgenus **Idiolimulodes**
- Elytral apices sub-truncate..... 9
9. Head with frontal carina (p. 574)..... Subgenus **Carinolimulodes**..... 10
- Head without frontal carina..... 11
10. Emargination of prosternal lobe sinuate (fig. 11); prothoracic tibiae (fig. 81) about twice as long as broad (p. 574)..... **L. (C.) brachyscelis**
- Emargination of prosternal lobe not sinuate (fig. 14); prothoracic tibiae (fig. 77) about three times as long as broad (p. 575)..... **L. (C.) philovagans**
11. Scutellum three and one-half times as broad as long; prothoracic tibiae (figs. 78-80) and mesothoracic tibiae (figs. 70-72) differing in chaetotaxy and proportions (p. 575)..... Subgenus **Ecitolimulodes**..... 12
- Scutellum six times as broad as long; prothoracic tibiae as in figs. 73-74, and mesothoracic tibiae as in figs. 63-64..... 14
12. Mesothoracic tibiae relatively short and broad (three times as long as broad); mesosternal carina long and slender (fig. 53); prosternal lobe (fig. 13) only moderately broad (p. 575)..... **L. (E.) stenotropis**
- Metathoracic tibiae elongate (four times as long as broad); mesosternal carina moderately broad; prosternal lobe (fig. 12) relatively broad..... 13
13. Mesosternal carina as shown in fig. 52 (p. 576)..... **L. (E.) bolivianus**
- Mesosternal carina as shown in fig. 56 (p. 576)..... **L. (E.) manni**
14. Mesocoxal capsules contiguous (fig. 2); pubescence of upper surface moderately long; terminal tergite with long setae (p. 568)..... Subgenus **Limulodes**
- Mesocoxal capsules separated (fig. 49); pubescence of upper surface short; terminal tergite with setae of moderate length (p. 570) Subgenus **Neolimulodes**

The following species of the family are not included in the above key: Argentina: *Limulodes tibialis* Bruch, *Limulodes argentinus* Bruch, *Limulodes elongatus* Bruch, *Cephaloplectus argentinus* Bruch; Brazil: *Limulodes heyeri* Wasm.; Panama: *Cephaloplectus godmani* Sharp; Mexico: *Limulodes mexicanus* Silv.; Australia: six species of *Rodwayia*.

### Genus *Limulodes* Matthews

*Limulodes* Matthews, 1867, Ann. Lyc. Nat. Hist. N. Y., 8, p. 409.

*Limulodes* Matthews, 1872, Trich. Illust. et Desc., p. 155.

*Limulodes* Matthews, 1884, Tran. Amer. Ent. Soc. 11, p. 123.

*Limulodes* Ganglbauer, 1899, Kafer v. Mitteleuropa 3, p. 296.

*Ecitoxenus* Wasmann, 1900, Zool. Jahrb., Syst. 14, p. 245.

*Limulodes* (= *Ecitoxenus*) Wasmann, 1908, Zoologica 11, No. 26, Second Edition, p. 182.

*Limulodes* Stickney, 1923, Ill. Biol. Monographs 8, No. 1, figs. 31, 177, 324, 469 (head capsule).

*Limulodes* Park, 1933, Ann. Ent. Soc. Amer. 26, pp. 357-360 (ecology).

Small species, usually less than a millimeter in length (excluding abdomen, which is more or less retracted). Upper surface covered with a fine pilosity, without long erect setae (except in *Cephaloplectodes*). Head (fig. 17) moderately broad, not markedly produced laterally and not "inflated" anteriorly to any extent (fig. 18). Antennal

fossae of moderate depth. Antennae ten-segmented, with a loose, three-segmented club. Pronotum laterally margined from base to apex, the hypomera joining the pronotal disc at an acute angle, more or less concave internal to margin. Mesosternal carina of variable form, always elevated and delimited from the mesosternum. Legs of variable form and chaetotaxy, anterior tibiae bearing a comb of spines on their outer margins.

*Genotype*.—*Limulodes paradoxus* Matthews.

*Remarks*.—The limits of the genus *Limulodes* as recognized in this paper are extremely broad and some of subgenera recognized may appear to be worthy of generic rank. It is the opinion of the writers that the material at hand is insufficient for the establishment of a generic classification and that for the present, the course of proposing subgenera to indicate the various degrees of relationship within the genus is a preferable one.

Each of these subgenera is to be considered as a species group, differing from all the others in a certain combination of characters rather than in the possession of any single character. The descriptions of the subgenera serve to call attention to these characters which are for the most part figured and need not be described in full

#### Subgenus *Limulodes sens. str.*

Antennae as illustrated in fig. 23. Scutellum broadly triangular, approximately six times as broad as long. Mesosternal carina broad, with sub-parallel sides, and with sub-truncate apex. Mesocoxal capsules contiguous internal to the carina. Metasternum little narrowed laterally (fig. 2). Tibiae slender in form, not expanded. Spermatheca in form of a simple loop (fig. 5).

*Type of Subgenus*.—*Limulodes* (L.) *paradoxus* Matthews  
Only one species is included in this subgenus.

#### *Limulodes paradoxus* Matthews

Figs. 2, 3, 5, 23, 59-63, 73

*Limulodes paradoxus* Matthews, 1867, Ann. Lyc. Nat. Hist. N. Y. 8, p. 412, pl. 15, 9 figs. Matthews, 1872, Trichopt. illust., p. 157, tab. 23, fig. 13, pl. 16. Matthews, 1884, Tran. Amer. Ent. Soc. 11, p. 124. Hamilton, 1889, Can. Ent. 21, p. 105 (records). Schwarz, 1890, Proc. Ent. Soc. Wash. 1, p. 244 (host record). Blatchley, 1910, Coleopt. of Indiana, p. 487. Silvestri, 1911, Boll. Lab. Zool. Portici 5, figs. 11, 12.

*Description* (based on specimens from Washington, D. C.)—Form broadly oval, convex. Color light brown. Upper surface clothed with very fine, moderately long, pale, recumbent pubescence. Antennae as shown in fig. 23, compressed.

Pronotum overlapping base of elytra, broadest at basal one-third, length at middle two-thirds that of breadth, sides evenly curved to anterior foramen which is more than one-third the width of pronotum. Posterior angles prolonged, fitting humeral elevations of the elytra.

Scutellum very broadly triangular, one-sixth as long as broad, concealed by base of pronotum. Elytra more than two-thirds

as long as broad, lateral margins flattened and somewhat expanded, converging very slightly to the very broadly, somewhat separately rounded apices; epipleurae forming a very acute angle with the elytra.

Abdomen usually telescoped under elytra in dried specimens, but with several apical segments extended beyond elytral apices when in alcohol. Tergites 6-9 uniformly clothed with strong setae, which become longer near apex of each tergite and successively longer towards the apex of the abdomen. The truncate terminal tergite bearing very long setae (equal to length of segment) at its apex and at apex of its ventrally reflexed lateral margins.

Anterior margin of prosternum feebly produced. Prosternal lobe (fig. 2) narrowest between coxae and widest just posterior to the coxae, from which point the sides converge somewhat posteriorly to the narrowly rounded apical angles; apical emargination arcuate.

Mesosternal carina (fig. 2) nearly as broad as visible width of coxae, sides fairly straight, slightly narrower at apex than between coxae. Mesocoxal capsules narrowly contiguous medially. Metasternum sparsely setose on lateral portions; on the median tumid region the setae become successively stronger posteriorly and are quite long and stout on the metasternal process between the hind coxae.

Third abdominal sternite (first visible) with about four somewhat irregular, transverse rows of strong, sub-equal setae. Successive sternites bearing finer setae except for their apical rows. Eighth sternite of female with apical margin arcuately produced; eighth of male shallowly emarginate. Lateral margins of ninth (?) tergite recurved ventrally and enclosing a sub-trapezoidal sclerite (which bears only a pair of fine sub-apical setae). This sclerite margined with a sharply delimited hyaline area which is emarginate at apex. Spermatheca of female as illustrated in fig. 5.

Legs with form and chaetotaxy as in figures 59-63, 73. The comb of spines of the outer margin of anterior tibiae composed of from ten to thirteen spines, with twelve or thirteen spines the usual number in the specimens examined. Inner margin with from five to eight spines in addition to spine at base of apical emargination of tibia. Middle tibia with six or seven spines on inner margin, and, in addition, a series of fewer and smaller submarginal spines on the posterior face.

Length (exclusive of abdomen), 0.76 mm.; width, 0.52 mm.

*Material Examined.*—*District of Columbia*: 11 specimens (6 on slides) from Washington (Hubbard, Schwarz coll., U. S. N. M., VIII : 5 : —). *Maryland*: 1 specimen (on slide) from near Plummer's Island (H. S. Barber coll., U. S. N. M., X : 7 : 33), 6 specimens (3 on slides) from Linden (J. E. Benedict coll., U. S. N. M., VII : 31 : 19). *Massachusetts*: 9 specimens (1 on slide) from Dracut (M. C. Z.), 2 specimens (1 on slide) from Tyngsboro (M. C. Z.). *Kentucky*: 12 specimens (5 on slides) from Elizabethtown (O. Park coll., IX : 3 : 34). *Arizona*: 5 specimens (3 on slides) from Williams (Barber, Schwarz coll., U. S. N. M., V : 25 : 01), 1 specimen (on slide) from Santa Rita Mts. (Hubbard, Schwarz coll., U. S. N. M., VI : 11 : —).

*Hosts*.—*Lasius umbratus mixtus* var. *aphidicola* (Walsh); Washington, D. C., and Elizabethtown, Ky., specimens. *Lasius (Acanthomyops) claviger* (Roger); Maryland (near Plummer's Isld.) specimen. *Lasius (Acanthomyops)* sp.; Linden, Md., examples. No host data are available for the Massachusetts and Arizona specimens.

*Remarks*.—The above redescription of *paradoxus* is based upon specimens from the District of Columbia which is one of the type localities. Matthews originally described this species as having nine-segmented antennae. In addition, the mesosternal carina, as figured, is much more slender in form than in any of the *Limulodes* from the United States before the writers. These and a number of other discrepancies between the specimens at hand and the original description and figures are, in all probability, errors in observation and interpretation due to the difficulty of studying such minute insects, so the writers feel confident that the District of Columbia series represents the same form that was before Matthews.

The specimens from Linden, Maryland, and from Arizona are at present referred to *paradoxus* despite a certain number of rather subtle differences. The six Maryland examples, in particular, seem to differ in their slightly larger size, their pale coloration, the somewhat different form of the apices of the elytra (the sutural angles are slightly rounded in the D. C. examples, right-angled in the Maryland specimens), and in the average chaetotaxy of the inner margins of the front and middle tibiae (spines on the inner margin of the front tibia average eight in the Maryland specimens and a little over six in the D. C. examples; the same averages prevail for the middle tibiae). Additional material is required to determine the significance of these variations.

### **Neolimulodes** new subgenus

Similar in form to subgenus *Limulodes*. Antennae as shown in fig. 24. Scutellum very broadly triangular, about six times as long as broad. Mesosternal carina (fig. 49) broad and flat, and but little narrowed at apex. Mesocoxal capsules separate internal to the mesosternal carina, connected by a narrow endoskeletal bar. Metasternum but little narrowed laterally (fig. 49). Anterior and middle tibiae (figs. 64, 74) slender, approximately four times as long as broad. Spermatheca as in subgenus *Limulodes*.

*Type of Subgenus*.—*Limulodes* (N.) *parki* n. sp.

*Remarks*.—This subgenus differs from all of the others in the separation of the mesocoxal capsules. In other respects it seems to be most closely allied to the subgenus *Limulodes*. Only one species is included in the subgenus.

### **Limulodes parki** new species

Figures 4, 8, 17-19, 24, 49, 64, 74

*Limulodes paradoxus* Wickham, 1892, Psyche 6, p. 322 (Iowa record, with *Aphaenogaster fulva* Rog.). Wickham, 1896, Psyche 7, p. 371 (Iowa record, with *Formica obscuripes* Forel). Park, 1933, Ann. Ent. Soc. Amer. 26, pp. 255-261 (Ecology).

Similar in form and color to *paradoxus* (fig. 4). Antennae as

shown in fig. 24. Pubescence of the upper surface shorter than in *paradoxus*. Prosternal lobe (fig. 8) narrowest between the coxae, rather abruptly broadened to one-half wider behind the coxae, thence converging with nearly straight sides to the apex, which is slightly broader than the intercoxal width. Apical emargination broadly arcuate. Mesosternal carina (fig. 49) slightly broader at middle than the visible width of coxa, its sides nearly straight and parallel to the sub-truncate anterior margin. Mesocoxal capsules not contiguous medially, connected by a transverse endoskeletal bar. Chaetotaxy of abdomen similar, in general, to *paradoxus*, but the setae of segment nine only one-half as long as in the latter. Form and chaetotaxy of legs as in figs. 64, 74. Anterior tibiae with eight to ten spines on the inner margin, and the outer margin with comb of 13-15 spines. Middle tibiae with eight or nine spines on the inner margin. Lamina of the posterior coxa with the lateral portion more prolonged posteriorly than in *paradoxus*.

Length, 0.92 mm. (not including abdomen).

*Types*.—Holotype, a female, mounted on a slide, in the collection of the writers; collected IV : 15 : 41 at Justice, Cook Co., Illinois, by C. H. Seevers. Paratypes: 65 specimens, same data as the holotype, collected by C. H. Seevers from five colonies of ants located in the same meadow, and distributed as follows: 47 in the collection of the writers, 10 in the U. S. N. M., 2 in the Amer. Mus. Nat. Hist., 4 in the collection of Orlando Park, and 2 in the Mus. of Comp. Zoology. Ten additional paratypes, same data as holotype, collected by R. L. Wenzel, are in the Field Museum of Natural History.

*Host of the Type Specimens*.—*Aphaenogaster fulva aquia* Emery.

*Other Material Examined*.—*Illinois*: 3 specimens from Argo, Cook Co. (C. Seevers coll., IV : 28 : 38), 8 specimens (4 on slides) from Champaign (O. Park coll., V : 22 : 33, VIII : 8 : 32), 4 specimens (1 on slide) from Peoria (O. Park coll., V : 28 : 33, X : 1 : 33), and 3 specimens (1 on slide) from southern Illinois (M. C. Z. coll.). *Indiana*: 4 specimens (1 on slide) from Valparaiso (M. Talbot coll., IV : 28 : 34). *Iowa*: 20 specimens (5 on slides) from Iowa City (Wickham coll., U. S. N. M., IV : 18 : —, V : 8 : —). *Texas*: 6 specimens (3 on slides) from San Antonio (F. C. Pratt coll., U. S. N. M., V : 15 : 06), and 1 specimen (on slide) from Columbus (Wickham coll., U. S. N. M.).

*Hosts of the Above Specimens*.—*Aphaenogaster fulva aquia* Emery; Argo, Illinois, Champaign, Illinois, Valparaiso, Indiana, and Iowa City, Iowa; *Leptothorax curvispinosus* Mayr; Peoria, Illinois; *Formica* sp., *rufa* group; Iowa City, Iowa; *Formica rufibarbis* var. *gnava* Buckley; San Antonio, Texas; *Pheidole dentata* Mayr.: Columbus, Texas.

*Remarks*.—Several references in literature to *L. paradoxus* have been based upon specimens of this new species which have been examined by the writers. *L. parki* is very distinct from that species and can easily be separated from it by the narrowly separated mesocoxal capsules (contiguous in *paradoxus*), the relatively short setae upon the terminal segment of the abdomen, the form of the mesotibiae, and by many other characters.



**Idiolimulodes** new subgenus

Form more convex than in the subgenus *Limulodes*. Pubescence of upper surface arranged in irregular, transverse rows (fig. 57). Antennae as shown in fig. 25, the two apical segments relatively short and broad. Scutellum triangular, less than four times as broad as long. Apices of the elytra angulately sinuate. Humeral elevations of elytra pronounced. Mesosternal carina (fig. 50) rather narrow in form, sides sub-parallel. Legs with anterior and middle tibiae (figs. 68, 75) slender in form, though proportionately shorter and broader than in subgenus *Limulodes*. Femora of middle legs constricted near base.

*Type of the Subgenus*.—*Limulodes* (I.) *navajo* n. sp.

*Remarks*.—The angulately-sinuate character of the apices of the elytra serves to separate this subgenus from all other *Limulodes*. In addition, the general form, the distribution of the pubescence on the upper surface, and the unusual form of the middle femora indicate that *Idiolimulodes* occupies a rather isolated position within the genus. Only one species of the subgenus is known.

**Limulodes navajo** new species

Figures 9, 25, 50, 57, 68, 75

*Limulodes paradoxus* Wickham, 1892, *Psyche* 6, p. 322 (locality record).

Form similar to *paradoxus*, but more convex. Color brown. Upper surface clothed with short, very fine pubescence arranged in irregular transverse rows. Antennae as shown in fig. 25. Scutellum broadly triangular, nearly four times as wide as long. Elytra (fig. 57) together a little broader than long, sides converging slightly to the angulately-sinuate apices. Humeral elevations exceptionally prominent. Anterior margin of the prosternum feebly produced. Prosternal lobe (fig. 9) widest immediately posterior to coxae, thence converging feebly with almost straight sides to the acute apical angles; apical emargination deeply, triangulately arcuate. Median portion of prosternum and lobe finely and sparsely pubescent. Mesosternal carina (fig. 50), at middle, more than two-thirds the visible width of the coxae and nearly twice as broad as the apical width; apex emarginate. Mesocoxal capsules broadly contiguous internal to carina. Metasternum with small, sparsely placed setae on lateral portions, its posterior lobe with an apical group of long, very strong setae. Third abdominal sternite (first visible) with about three transverse rows of long, very strong setae. Fourth, fifth, and sixth sternites each with an apical row of less developed setae and with a few small setae intermingled. Seventh and eighth sternites with smaller setae, these increasing in size to the stronger apical row. Posterior margin of eighth sternite sinuately emarginate at the middle in the male. The terminal tergite with ventrally reflexed margins enclosing the ninth sternite, densely setose, setae successively stouter apically. Legs with form and chaetotaxy as in figures 68, 75.

Length, 0.69 mm. (exclusive of abdomen); width, 0.53 mm.

*Holotype*.—A male, in the United States National Museum collection, from Walnut, Arizona; collected VII : 21 : —, by Wickham.

*Host*.—Unknown.

**Cephaloplectodes** new subgenus

Form broader and more depressed than in subgenus *Limulodes*. Dorsal surface with longitudinal rows of long, erect setae in addition to the fine, short, recumbent pubescence. Antennae as shown in fig. 26. Scutellum triangular, less than three times as broad as long. Mesosternal carina (fig. 51) with sides converging to the sub-acute apex. Metasternum rather strongly narrowed laterally (fig. 51). Anterior and middle tibiae (fig. 69, 76) short and broad (approximately two and one-half times as long as broad); the marginal comb of spines of the anterior tibia continued around the apex at an angle of approximately 90 degrees.

*Type of Subgenus.*—*Limulodes* (C.) *pallidus* n. sp.

*Remarks.*—This subgenus is strikingly similar in facies to the genus *Cephaloplectus*. The broad depressed form and the presence of rows of long, erect setae upon the dorsal surface are particularly reminiscent of certain species of *Cephaloplectus*. In other characters, particularly head structure, *Cephaloplectodes* falls within the present broad concept of the genus *Limulodes*, where it occupies, however, a distinctly isolated position. Only one species is known.

**Limulodes pallidus** new species

Figures 10, 26, 51, 58, 69, 76

Form broader and more depressed than that of *paradoxus*. Color pale yellow. Dorsal surface uniformly clothed with short, fine, pale, recumbent pubescence and with long, fine, erect setae intermingled; these are distributed in ten irregular longitudinal rows of about ten setae each. Antennae as shown in fig. 26. Scutellum triangular (fig. 58), less than three times as broad as long. Elytra (fig. 58) nearly three-fourths as broad as long, sides converging very slightly to the very broadly, somewhat separately, rounded apices. Anterior margin of prosternum feebly produced; prosternal lobe (fig. 10), posterior to coxae, becoming nearly twice as broad as intercoxal width, thence converging feebly, with straight sides, to the very acute apical angles. Apical emargination deep, arcuate. Mesosternal carina narrowly triangular in form, more abruptly narrowed just before the slightly rounded apex. Third sternite with two transverse rows of similar setae; sternites 4–6 each with an apical row of strong setae (which diminish in size on each successive segment) and two or three transverse, irregular, sub-apical rows of much smaller setae; sternites seven and eight clothed uniformly with small, stout setae which increase in size toward the apex of each segment; reflexed margins of ninth tergite with stout, long (especially toward apex) setae. Form and chaetotaxy of legs as in figs. 69, 76.

Length, 0.88 mm. (exclusive of abdomen).

*Types.*—Holotype, a male, in the U. S. N. M. collection, from Guadalajara, Jalisco, Mexico; collected in December by W. M. Mann. Paratype, a male, same data as the type, deposited in the collection of the writers.

*Host.*—*Eciton* (*Acamatus*) sp.

**Carinolimulodes** new subgenus

Form of subgenus *Limulodes*. Antennae as shown in fig. 29. Margins of lateral expansions of head continued as a carina across the front, separating a sharply declivous transverse anterior area from the dorsum. Scutellum triangular, transverse, approximately five times as broad as long. Anterior margin of prosternum more distinctly produced than in the other *Limulodes*. Prosternal lobe with sub-parallel sides, apical emargination shallow. Mesosternal carina (figs. 54, 55) moderately broad, apex broad, shallowly emarginate. Metasternum little narrowed laterally.

*Type of Subgenus*.—*Limulodes* (C.) *brachyscelis* n. sp.

*Remarks*.—This subgenus is proposed for two new species, *brachyscelis* from Panama and *philovagans* from Ecuador, which differ most strikingly from the other species in possessing the frontal carina. In a number of other characters (especially the form of the tibiae), the two species show a marked degree of structural divergence.

**Limulodes brachyscelis** new species

Figures 11, 29, 54, 65, 66, 81

Antennae illustrated in fig. 29. Scutellum broadly triangular, about five times as broad as long. Anterior margin of prosternum distinctly produced. Prosternal lobe (fig. 11) two-fifths broader than intercoxal width, thence with straight almost parallel sides to the acute apical angles; apical emargination shallow, bisinuate. Mesosternal carina (fig. 54), at middle, broader than visible width of coxa, sides converging anteriorly to the emarginate apex, which is about three-fifths the median width of carina. Mesocoxal capsules narrowly contiguous internal to mesosternal carina. Metasternum finely and sparsely setose laterally, median lobe with long, strong setae. Third sternite (first visible) with several transverse, irregular rows of strong setae; sternites 4–8 with an apical row of strong setae which successively diminish in size, and a row of small sub-apical setae which increase in size on each successive sternite; reflexed margins of the terminal tergite closely clothed with long, stout setae. Form and chaetotaxy of tibiae as in figs. 65, 66, 81.

Length, 0.88 mm. (exclusive of abdomen).

*Types*.—Holotype, a male (on slide), in the collection of the writers, from Barro Colorado Island, Canal Zone; collected VII : 29 : 36, by Orlando Park. Paratypes, three specimens, same data as type, two in writer's collection, and one in the U. S. N. M. collection.

*Host of the Type Specimens*.—*Eciton burchelli* Westwood.

*Remarks*.—These specimens were taken from a mason jar of army ants collected by Dr. O. Park from a huge, overnight "nest" of the ants on Barro Colorado Island. This jar of ants proved quite profitable since a large series of *Cephaloplectus mus* Mann were also taken from it by the writers.

**Limulodes philovagans** new species

Figures 14, 30, 55, 67, 77

Antennae as in *parki* (fig. 30). Scutellum approximately five times as broad as long. Elytra a little broader than long. Anterior margin of prosternum distinctly, arcuately produced. Prosternal lobe (fig. 14) one and two-thirds as broad posterior to the coxae as the intercoxal width, thence with straight, very feebly converging sides to the acute apical angles; apical emargination shallow, evenly arcuate. Mesosternal carina (fig. 55) about as broad at middle as visible width of coxa, thence with feebly curved sides to the slightly narrower, medially notched, apex. Mesocoxal capsules broadly contiguous internal to the mesosternal carina. Metasternum with chaetotaxy as in *parki*. Chaetotaxy of abdomen as in *parki*. Tibiae with form and chaetotaxy as in figs. 67, 77.

Length, 1.2 mm. (exclusive of abdomen).

*Types*.—Holotype, a male, in the U. S. N. M. (W. M. Mann collection), from Mera Oriental (30 miles E. N. E.), Ecuador; collected II : 14 : 22, by F. X. Williams. Paratypes, five examples, with the same data as the type, two in the U. S. N. M. collection, and three in the collection of the writers.

*Host*.—*Eciton vagans* Olivier.

**Ecitolimulodes** new subgenus

Form similar to that of subgenus *Limulodes*. Scutellum approximately three and one-half times as broad as long. Mesosternum (fig. 53) narrowly carinate, the apex of the carina expanded and feebly notched at middle. Metasternum rather strongly narrowed laterally. Spermatheca of female more complex (fig. 6) than in subgenus *Limulodes* (fig. 5).

*Type of the Subgenus*.—*Limulodes* (E.) *stenotropis* n. sp.

*Remarks*.—This subgenus is erected for three new species, *stenotropis*, *manni*, and *bolivianus*, which differ from the other species in the genus by the combination of characters mentioned above. No single character can adequately separate them from all of the other subgenera.

**Limulodes stenotropis** new species

Figures 6, 13, 27, 53, 70, 78

Prosternal lobe one-half broader, posterior to coxae, than intercoxal width, thence with nearly straight, feebly converging sides to the very acute apical angles; apical emargination rather deeply, triangulately arcuate (fig. 13). Mesosternal carina (fig. 53) slightly wider at middle, than visible width of coxae, thence narrowed to the slightly expanded apex, which is about one-third of the median width and feebly emarginate at middle. Lateral portion of metasternum, sparsely clothed with short stout setae; median gibbous portion and posterior lobe with more closely placed long, stout setae. Third sternite (first visible) with long, stout setae, sternites 4–8 with small, closely placed setae on apical half of each sternite; these increase in size apically on each sternite; tergite nine (terminal) bearing long,

strong setae. Posterior margin of sternite 8 shallowly, arcuately emarginate at middle in the male, and with a shallow notch on each side of the median emargination. Form and chaetotaxy of front and middle tibiae as shown in figs. 70, 78. Spermatheca as illustrated by fig. 6.

Length, 0.84 mm. (exclusive of abdomen).

*Types*.—Holotype, a female (on slide), in the U. S. N. M. collection (Nevermann collection). The types, without data, were almost certainly collected by Nevermann in Costa Rica. Paratypes, nine examples in the U. S. N. M. collection, and six specimens in the collection of the writers.

*Host*.—Unknown.

***Limulodes manni* new species**

Figures 28, 56, 71, 79

Similar to *stenotropis*, but differing in the following respects: prothoracic tibiae (fig. 79) elongate, more than three times as long as wide (two and one-half times as long as wide in *stenotropis*), the outer marginal comb of the prothoracic tibiae with an average of 19 spines (16 in *stenotropis*), the inner margin with an average of 11 spines (8 in *stenotropis*). The middle tibiae (fig. 71) more elongate than in *stenotropis* and with an average of 12 spines (excluding the apical group) on the inner margin (9 in *stenotropis*). Hind tibiae more than four times as long as wide (approximately three times as long as wide in *stenotropis*).

Length, 0.93 mm. (exclusive of abdomen).

*Types*.—Holotype, a male (on slide) in the U. S. N. M. (W. M. Mann collection), from Colombiana, Costa Rica; collected III : — : 24. Paratype, a male, same data as the type, deposited in the collection of the writers.

*Host*.—Unknown.

***Limulodes bolivianus* new species**

Figures 12, 52, 72, 80

This species is very close to *manni*, from which it differs chiefly in the form of the mesosternal carina (fig. 52).

Length, 0.94 mm. (exclusive of abdomen).

*Types*.—Holotype, a female, in the U. S. N. M. (W. M. Mann collection), from Rio Negro, Rio Beni, Bolivia; collected in January by W. M. Mann. Paratype, a male, same data as the type, deposited in the collection of the writers.

*Host*.—*Eciton coecum* Latreille.

**Subgenus Undetermined**

The following five species of *Limulodes* have not been available for study, so it is difficult to place them in the subgenera herein described. There is very little available information concerning these species as most of them are described in very general terms. As pointed out previously, these minute beetles can be studied adequately

only after being placed on slides and examined with the compound microscope. Those species which were described without benefits of this technique are almost complete mysteries. Some of the species were described after studies of slide preparations, but the investigators failed to utilize many of the valuable characters present or described them inadequately. Fortunately, many of these species may be recognized on the basis of locality and host data.

### ***Limulodes heyeri* (Wasmann)**

*Ecitoxenus heyeri* Wasmann, 1900, Zool. Jahrb., Syst. 14, p. 245, pl. 14, fig. 14.

*Limulodes heyeri* Wasmann, 1908 (1909), Zoologica 11, No. 26, Second Edition, p. 182. Silvestri, 1911, Boll. Lab. Zool., Portici 5, p. 187.

Wasmann first assigned this species to the staphylinid subfamily Cephaloplectinae but later referred it to *Limulodes*. The original description is wholly inadequate. It is probable that *bolivianus* n. sp. is close to *heyeri* since both occur with *Eciton coecum* Latreille. Should these two species prove to belong to the same subgenus, the name *Ecitoxenus* will properly replace *Ecitolimulodes* herein proposed.

*Type Locality*.—São Leopoldo, Santa Catharina, Brazil.

*Host*.—*Eciton coecum* Latreille.

### ***Limulodes mexicanus* Silvestri**

*Limulodes mexicanus* Silvestri, 1911, Boll. Lab. Zool. Portici 5, p. 186, 14 figs.

Silvestri described this species in a general way and compared it with *paradoxus*, from which it apparently differs in many respects. Unfortunately, the description and figures are not very helpful in relating this species to the other neotropical forms known to us. The most useful of Silvestri's illustrations are those of the legs, the chaetotaxy of which seems to be moderately well figured. This species may be allied to *stenotropis* n. sp. or *manni* n. sp. from Costa Rica, although this is by no means evident, for the mesothoracic tibiae differ considerably in shape and chaetotaxy. There will probably be little difficulty in recognizing this species when collected, since it occurs with *Cheliomyrmex*, the only other genus of army ants besides *Eciton* in the new world.

*Type Locality*.—Orizaba, Vera Cruz, Mexico.

*Host*.—*Cheliomyrmex nortoni* Mayr.

### ***Limulodes argentinus* Bruch**

*Limulodes argentinus* Bruch, 1922, Physis 5, p. 299, figs. a, b, c. Bruch, 1924, Physis 7, fig. b.

This species and the following two Argentine species are probably characterized well enough to enable one to determine species from that country, but the descriptions and figures offer little basis for comparison with species at hand. Bruch likens *argentinus* to *paradoxus*, and states that it is considerably different from *mexicanus* and *heyeri* but gives no explanation of these comparisons.

*Type Locality*.—Alta Gracia, Córdoba, Argentina.

*Host*.—*Pheidole triconstricta* var. *ambulans* Emery.

***Limulodes elongatus* Bruch**

*Limulodes elongatus* Bruch, 1924, *Physis* 7, p. 229, fig. a (1-6).

This species appears to be unusual enough to be readily recognized. The illustrations of habitus, antennae, and seminal receptacle should prove helpful. The intermediate segments (3-6) of the antennae are elongated rather than being transverse as in most other species. This is a large species, measuring 1.2-1.6 mm. in length.

*Type Locality*.—Fives Lille, Argentina.

*Hosts*.—*Acromyrmex* (*A.*) *lundi* Guérin and *Acromyrmex* (*Moellerius*) *heyeri* Forel.

***Limulodes tibialis* Bruch**

*Limulodes tibialis* Bruch, 1926, *Revista Soc. Ent. Argentina* 1, No. 2, p. 11, 5 figs.

*Type Locality*.—Cabana, Argentina.

*Host*.—*Eciton dulcius jujuyense*.

**Genus *Paralimulodes* Bruch**

*Paralimulodes* Bruch, 1919, *Physis* 4, p. 579, 3 figs.

The writers have not seen specimens of this genus but on the authority of Bruch it differs from *Limulodes* in having fewer antennal segments, antennal form, structure of the prosternum and mesosternum, and in having unarmed tibiae. It is strange that Bruch did not state the exact number of antennal segments present, for it is difficult to determine from the figure whether there are eight or nine. Nor is it easy to determine from the description and figure in just what respects the prosternum and mesosternum differ from those of *Limulodes*. It is of interest to note the unarmed tibiae but with respect to other characteristics, the legs are not well illustrated. It appears that this species is unusual enough to merit the generic rank accorded it by Bruch, but the differences need to be more clearly elucidated for further taxonomic studies.

A single species, *P. wasmanni* Bruch (1919, p. 590) has been described. It was based on two males collected from a colony of the army ant, *Eciton spegazzini* Emery, at La Plata, Argentina.

**Genus *Rodwayia* Lea**

*Rodwayia* Lea, *Tasmanian Naturalist* 1, 1907, p. 14.

A single species (*R. orientalis* Lea) of this Australian genus is before the writers. *Rodwayia* is the only known limulodid genus occurring outside the Americas. Despite its wide geographic isolation, this genus appears to be closely related to the genus *Limulodes* (particularly to the subgenus *Neolimulodes*).

*Rodwayia* differs from *Limulodes* most notably in the absence of a comb of spines on the outer margin of the tibiae and in the form of the mesosternal carina. The latter is moderately broad, with sub-parallel sides, and is acutely produced at apex. In contrast to all the other genera, the carina, just before its apex, is incompletely delimited from the mesosternum; its sides slope gradually to the level of

the mesosternum. The mesocoxal capsules are narrowly separated, a condition noted elsewhere only in *Neolimulodes*. The legs are similar in form (though somewhat shorter and stouter) to *Neolimulodes*, but differ conspicuously in the unusual length of the tarsi which are approximately one-half the length of the tibiae (about one-third the tibial length in *Neolimulodes*). The posterior coxae are separated by approximately two-thirds their width (separated by a distance equal to the coxal width in *Neolimulodes*).

Six species of the genus have been described: *Rodwayia ovata* Lea (1907, p. 15), *Rodwayia occidentalis* Lea (1907, p. 16), *Rodwayia orientalis* Lea (1907, p. 16), *Rodwayia minuta* Lea (1907, p. 16), *Rodwayia intercoxalis* Lea (Tran. Royal Soc. S. Aust. 43, 1919, p. 174, pl. 25, fig. 13), *Rodwayia grandis* Deane (Proc. Linn. Soc. N. S. W. 55, 1930, p. 485, figs. 18, 19). These were collected in various localities in Queensland, Victoria, South Australia, New South Wales, and Tasmania. The available host data are recorded elsewhere in the paper (p. 563).

### Genus *Cephaloplectus* Sharp

*Cephaloplectus* Sharp, 1883, Biol. Cent.-Amer. 1 (2), p. 295.

Head, pronotum and elytra beset with rows of erect setae. Head (fig. 15) very broad, approximately four times as broad as the labrum; the head capsule produced laterally as arcuate lamellae anterior and ventral to the antennal fossae. The strongly "inflated" head capsule (fig. 16) extends considerably beyond the labrum. Anterior arm of tentorium very short (fig. 15). Antennal fossae extremely deep, almost contiguous.

Antennal form distinctive (fig. 15); the arcuate, cylindrical scape very long; the somewhat shorter second segment as long as segments 3-7 combined; segments 3-9 feebly incrassate, the ninth longer than the others; the tenth segment narrower than the preceding and rounded at tip; segments 3-10 compressed.

Labrum transverse, nearly twice as broad as long (width: length :: 13:7). Mentum transverse, nearly twice as broad as long, feebly trapezoidal, apical margin moderately arcuate. Maxillary palpi as illustrated in fig. 20.

Mesocoxal capsules contiguous; mesosternal carina triangular, acute at apex. Legs (figs. 36-43) distinctive in form, in the arrangement of spines, and especially in the structure of the tarsi (described in morphological section). Spermatheca (fig. 7) very extensively coiled.

*Genotype*.—*C. godmani* Sharp.

*Remarks*.—Although nine species of *Cephaloplectus* have been described or mentioned by name, it is impossible to identify a single one by consulting the literature. The confused status of the species has resulted from inadequate description and from the deplorable practice of assigning names without giving any description at all. We are not able to solve all of the problems encountered but hope to eliminate some of the confusion by a restudy of the Mann types and by regarding Wasmann's species as *nomina nuda*.



It is unfortunate that the identity of the genotype *godmani* cannot be established without reference to the type specimen. Sharp's description of this species is vague and furnishes few clues as to its identity. The validity of *mus* Mann is dependent upon finding it different from *godmani*, for there is no reason at present for regarding it as a distinct species. The writers believe that *mus* will prove to be a synonym of *godmani* but until the type of the latter can be examined, *mus* must be recognized. There seems to be no alternative at the present time to identifying our Panamanian specimens as *mus* if for no other reason than that the types of that species are available for comparison. No attempt will be made to establish *godmani*.

In a paper entitled "Ameisenmimikry," Wasmann (1925, p. 50, 51) referred to three new species of *Cephaloplectus* from Brazil by the names *insignis*, *longiseta*, and *quadriglumis*, noted their lengths, and stated in the preface to the paper that further descriptions of these and many other species of ant guests, mentioned only by name, were to be given in a later work. This subsequent paper, which was to have been entitled "Zur Kenntnis der Gäste von *Atta* und *Eciton*" and which was to have been published in the *Memorie della Pontifica Accademia della Scienze Nuovi Lincei*, apparently did not appear; the writers have been unable to locate it and Borgmeier (*Revista Ent.* 1, 1931, p. 355) stated that it was not published. It can only be concluded that the three names mentioned above are *nomina nuda* since the measurements of body length scarcely constitute descriptions.

Bruch tentatively identified Argentine specimens in his collection as *godmani* but pointed out that they differed in minor details from Sharp's description of that species. He suggested that should these specimens prove to be different, the name *argentinus* be applied to them. In spite of the fact that this practice of assigning provisional names is to be discouraged, it is very likely that his specimens are distinct so that the name *argentinus* must be recognized.

The type specimens of *flavus* Mann, *trilobitoides* Mann, and *pusillus* Mann were examined by the writers, and it is our opinion that *pusillus* is a synonym of *trilobitoides*.

### *Cephaloplectus godmani* Sharp

*Cephaloplectus godmani* Sharp, 1883, *Biol. Cent.-Amer.* 1 (2), p. 297, pl. IV, fig. 1.

The original description of this species is as follows: "Head scarcely visible, antennae concealed. Thorax very large, hind angles much produced backwards. Elytra not so long and scarcely so broad as thorax, a little narrowed behind, hind angles extremely obtuse, no visible punctation, but an excessively fine transverse rugulosity, in this respect resembling thorax. Hind body paler than anterior parts; dense depressed pubescence. 4 mm." The unique type specimen was collected in the track of *Eciton* in a dense forest near Bugaba, Panama.

The above description is too vague to enable us to identify this species. The size is apparently the most important clue in the description. We have specimens from Panama which we would undoubtedly regard as *godmani* were it not for the fact that they cannot be dis-

tinguished from the type of *mus*. This leads us to believe that *mus* is a synonym of *godmani* but we are unable to corroborate this view.

### ***Cephaloplectus argentinus* Bruch**

*Cephaloplectus godmani* (?), provisional name of *argentinus*, Bruch, 1926, Revista Soc. Ent. Argentina 1 (2), p. 4, figs. 1-4.

The identification of the specimens of *Cephaloplectus* from Argentina by Bruch was made with great reluctance since Sharp's description of *godmani* gave him no basis for comparison. Although he suspected that his specimens were different, he did not exactly describe them as new but merely suggested that the name *argentinus* be used in case they should prove to be distinct. Bruch's notes and figures do not offer much aid in determining whether his specimens differ from those that we have before us. Possibly they may be closer to *flavus* than to *godmani* since they are small (2.5 mm. in length) and are pale yellow in color. Its occurrence with different hosts and its wide geographical separation from the Panama species lend some support to the belief that *argentinus* is probably distinct.

*Hosts*.—*Eciton hetschkoi* Mayr (Alta Gracia, Córdoba, Argentina) and *Eciton dulcius jujuyense* (Cabana, Argentina).

### ***Cephaloplectus mus* Mann**

Figures 1, 7, 15, 16, 20-22, 31, 33-48

*Cephaloplectus mus* Mann, 1926, Jour. Wash. Acad. Sci. 16, p. 452.

The conclusions concerning this species must be somewhat tentative since a study of material at hand from Ecuador, Panama, and Costa Rica raises questions which can be answered only by the examination of many more specimens. This was emphasized when an attempt was made to identify a series of 75 specimens of the genus collected by Dr. Orlando Park from a huge cluster of *Eciton burchelli* Westwood hanging from a tree on Barro Colorado Island. This series is readily separated into two groups on the basis of size; the 69 smaller individuals average 2.6 mm. in length and six larger individuals average 3.75 mm. in length. Whatever variation exists in each group is due largely to the degree of contraction of the abdomen and the two groups do not overlap. Careful scrutiny has failed to reveal any qualitative differences between the two groups and there are few indications of quantitative differences other than that of size. The larger individuals resemble very closely the type of *mus* and are identified as that species. The smaller individuals evidently represent a distinct population even though occurring in the same colony of army ants. Without more material from other colonies, we are reluctant to assign the smaller individuals to any special category, so shall regard them tentatively as a small form of *mus*.

*Description* (Typical form).—Color reddish-brown. Head clothed with recumbent hairs, the pronotum and elytra transversely rugulose and densely pubescent, the pubescence arranged in transverse rows between the fine ridges. Head, pronotum and elytra beset with irregular rows of long, pale setae as follows (since the number of setae in a row is variable, these figures are averages): head with five trans-

verse rows of 10 setae each, pronotum with 11 transverse rows comprised of 12 setae in the apical row and 20 in the basal row, elytra with 10 transverse rows of 10–12 setae. Abdomen without erect setae but rather densely clothed with recumbent hairs, those near the apex longer. Metasternum and third sternite (between metathoracic coxae) beset with many stout, spinose setae, and the terminal abdominal sclerites bear long setae.

Prosternal lobe moderately large, the maximum width is approximately three-tenths as wide as the pronotum. Mesosternal carina moderately stout, apex acute, rounded.

Legs beset with spines and setae as illustrated in figures 39–43. Prothoracic tibia with a comb of short spines along the lateral and apical margins; the total number of spines along both borders is rather constant except for one specimen—33 to 35 as a rule, 42 in an Ecuadorian example. Mesothoracic femora bearing five rather stout spines along the medial border and variable number along the apical border.

Male possessing a comb of spines in the emargination of the eighth sternite.

Length, 3.2–4 mm. (av. 3.75 mm.); length of head, pronotum and elytra, 2.3–2.35 mm.; width of pronotum, 1.82–1.96 mm.

*Remarks.*—The smaller individuals of *mus* appear to differ from typical examples in the following respects, most of which are of a minor nature: the uniformly smaller size, the variation within the two groups is discontinuous; the coloration varies from light reddish-brown to yellowish; the mesosternal carina is slightly more acute at apex and more slender; the prothoracic tibiae bear 28–32 spines in the comb along the lateral and apical margins; the prosternal lobe is only one-fourth as wide as the pronotum; the spines along the medial border of mesothoracic femora are not as strong. Length of small individuals, 2.25–2.9 mm. (av. 2.6 mm.); length of head, pronotum and elytra, 1.68–1.75 mm.; width of pronotum 1.2–1.3 mm.

*Material Examined.*—Holotype, one paratype and two other examples from Mera Oriental, Ecuador (Mann coll., U. S. N. M.); one specimen from Hamburg Farm, Costa Rica (Nevermann coll., U. S. N. M.); and six large individuals and 69 small examples from Barro Colorado Island, Canal Zone (coll. by O. Park).

*Hosts.*—*Eciton vagans* Olivier (Ecuador, Costa Rica); and *Eciton burchelli* Westwood (Panamá).

### ***Cephaloplectus flavus* Mann**

*Cephaloplectus flavus* Mann, 1926, Jour. Wash. Acad. Sci. 16, p. 452.

This species differs from *mus* in the following respects: (1) the pale yellowish coloration; *mus* is typically reddish-brown although the small form may be almost as pale as *flavus*. (2) the smaller size; *mus* is typically a larger species but the smaller form agrees with *flavus* in size. (3) the presence of a row of about 15 setae along the apical margins of the elytra (more easily seen in slide preparations). (4) the prosternal lobe is larger in proportion to the prothorax; the maximum width is approx-

imately one-third the width of the pronotum. (5) the row of spines along the lateral and apical margins of the prothoracic tibiae is comprised of 42 spines; *mus* typically has only 32–35 spines in this row (one example has 42) and the small form bears only 28–32. (6) the arrangement of spines on the mesothoracic femora is somewhat different.

Length, 2.5–2.75 mm.

*Material Examined*.—One paratype and one other example (slide mount) from Hamburg Farm, Reventazon, Costa Rica (Mann coll., U. S. N. M.).

*Host*.—*Eciton* (*Labidus*) *praedator* F. Smith.

### ***Cephaloplectus trilobitoides* Mann**

Figure 32

*Cephaloplectus trilobitoides* Mann, 1926, Jour. Wash. Acad. Sci. 16, p. 452.

*Cephaloplectus pusillus* Mann, 1926, J. Wash. Acad. Sci. 16, p. 453. New synonym.

Color light reddish-brown. Head moderately pubescent, pronotum and elytra densely so, the pubescence in transverse rows. Head, pronotum and elytra bearing long setae in moderately regular rows as follows: head with several transverse rows of five setae each, pronotum and elytra with 10 longitudinal rows and approximately five transverse rows. Metasternum and abdominal segments conspicuously beset with long, rather strong needle-like setae, the subapical setae of the tergites and sternites frequently longer than the segment (several of the setae of the metasternum and third sternite are stout and spinose). The ninth abdominal segment bears a ring of about 16 long, needle-like setae at its base (these setae are as long as the segment), and numerous other shorter setae on sides and apex. Medial border of mesothoracic femora bears a row of submarginal setae but they are very small compared to those of *mus* and *flavus*.

Emargination of prosternal lobe somewhat shallower than in *mus* and *flavus*; the depth of emargination is about one-fourth the width of apex, while in *mus* and *flavus* it is about one-half the width of apex. Apical margin of elytra (fig. 32) transverse for a short distance laterally where it forms almost a right angle with the lateral border, then oblique until near the suture.

Apical margin of eighth sternite incised medially in the male but not bearing comb of spines as in *mus* and *flavus*.

Length, 1.6–2 mm. (variation due to contraction of abdomen); length of head, pronotum and elytra, 1.25 mm.; width of pronotum, 1 mm.

*Material Examined*.—Holotype from Escuintla, Guatemala (Mann coll., U. S. N. M.); one specimen from Costa Rica (Nevermann coll., U. S. N. M.), identified by writers; and holotype of *C. pusillus* Mann (U. S. N. M.) from Hamburg Farm, Costa Rica.

*Host*.—*Eciton coecum* Latreille.

*Remarks*.—This species is easily distinguished from *mus* and *flavus* by its chaetotaxy, the form of the prosternal lobe, the apical margin of the elytra, and in the absence of the comb of spines from the eighth male sternite.

The writers have concluded, after an examination of the type specimens, that there is no justification for regarding *pusillus* as a valid species, since there are no apparent criteria for separating it from *trilobitoides*. The comparison of the types was not as complete as desired because of the fact that the specimens are mounted on points in such a way as to obscure the detailed structure of several of the legs. Upon first examining the specimens, they appear to differ in the chaetotaxy of the abdomen but these apparent differences vanish when the degree of telescoping of the abdominal segments is taken into consideration, and it is noted that some of the setae are almost hidden in one of the types.

### Genus *Eulimulodes* Mann

*Eulimulodes* Mann, 1926, Jour. Wash. Acad. Sci. 16, p. 453.

Head capsule constructed, in general, like that of *Cephaloplectus*, with deep antennal fossae, and with the roof of the fossa produced laterally. Head broad, three times as wide as the labrum. Labrum trapezoidal, somewhat narrower at apex than base (3 : 5), width at apex approximately equal to the length. Mentum approximately as wide as long.

Antennae similar in form to those of *Limulodes*. Scape not visible in specimens at hand, second segment robust, segments 3-8 small, the eighth broader than the others, ninth segment transverse, tenth a little longer and narrower than the ninth, rounded at apex.

Second segment of the maxillary palpus elongated, the proximal part very slender, while distally it is expanded rather abruptly into a club; the compressed third segment a little longer than the second and rather evenly widened from base to the obliquely truncated apex; fourth segment moderately long, slender.

Prosternum in front of the coxae somewhat longer than in *Cephaloplectus*, while the prosternal lobe is proportionately shorter and broader. Length of prosternal lobe, measured from narrowest point between coxae to the apex, is approximately equal to the maximum width, while in *Cephaloplectus* the lobe is only two-thirds to three-fourths as broad as long (the measurement of breadth in *Eulimulodes* does not include the sides of the lobe which are visibly flanged behind the coxae). Apical emargination of prosternal lobe shallow, about one-half as deep as the width of the apex.

The pronotal hypomera medial to the lateral margin strongly convex before being deflexed dorsad to meet the prosternum; this convexity is continuous with the convexity of the head ventrally. Pronotal margin not visible ventrally but easily seen from side.

*Genotype*.—*Eulimulodes mexicanus* Mann.

*Remarks*.—The principal characteristics which distinguish this genus from *Cephaloplectus* may be summarized as follows: the absence of erect setae; antennae of the *Limulodes* type; the form of the second and third segments of the maxillary palpi; the shorter and broader prosternal lobe; the convex pronotal hypomera.

**Eulimulodes mexicanus** Mann

*Eulimulodes mexicanus* Mann, 1926, Jour. Wash. Acad. Sci. 16, p. 454.

Color reddish. Head, pronotum and elytra uniformly clothed with recumbent pubescence, the fine hairs arranged in longitudinal rows. Abdomen rather uniformly covered with moderately long, pale setae.

Length, 1.9 mm.; length of head, pronotum, and elytra, 1.5 mm.; width of pronotum, 1.1 mm.

**Material Examined.**—One paratype from Ixtlán, Nayarit, Mexico (Mann coll., U. S. N. M.).

**Host.**—*Eciton* (*Neivamyrmex*) *wheeleri* Emery.

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## BOOK NOTICES

JOHN RAY, NATURALIST, HIS LIFE AND WORKS, by CHARLES E. RAVEN, D.D. xix and 502 pp., frontispiece portrait. 1942. Octavo, linen bound. Published by THE CAMBRIDGE UNIVERSITY PRESS: for sale by THE MACMILLAN COMPANY, INC., 60 Fifth Ave., New York. Price, \$7.00.

For twenty years the writer of this notice has browsed through the literature on the history of entomology. In that twenty years no full or satisfactory life of John Ray, the father of modern taxonomy, could be found. All accounts, when they came to the picture of his times, his home life, personal habits and methods of study were brief to the point of barrenness. On the other hand, all treated John Ray with the utmost respect even to the ultimate distinction of referring to him as the father of modern botany or the father of modern zoology. The reserved English in 1844 paid him the high honor of using his name for a biological society, the Ray Society, organized for the publication of outstanding works in the field of biology.

John Ray (or Wray) was born in 1627 and died in 1705. In this first century of organized science, through the yet widespread shadows of medieval ignorance and even bigotry, his personal figure moves dim and almost spectral; dim it is because of our meagre knowledge of the man John Ray himself and spectral because careful analysis of his extensive treatises on both plants and animals shows a vast first-hand knowledge of forms and an astonishing insight into species relationships *inter se*, of variation, of evolution of form into further forms and the beginnings of a sound classification based on comparative anatomy. In many groups he defined genera and species clearly and used a binomial nomenclature. However, in other groups less well known he used a less concise terminology. The great amount of his first-hand work with plants and animals themselves as shown by his extensive correspondence and publications gave him an accurate insight into the nature of living forms, while in succeeding centuries the recognition of this uninterrupted study covering fifty-five years helped built the respect of later students into the dim figure of a superman. His most extensive work which summarized his knowledge of botany, *Historia Plantarum Generalis*, 1686, 1688, 1704, comprises 2,860 closely printed folio pages (Nordenskiöld, 1932). It lists all plants known at the time, 18,600 (Singer, 1931). At the death of his wealthy coworker, Willughby, in 1672, Ray turned to zoology. He first rewrote and completed Willughby's *Ornithologia* (1676), then in 1686 published Willughby's *Historia Piscium*, in 1693 his own *Synopsis Quadrupedum* and in 1704 *Methodus Insectorum*. After his death, 1710, was published *Historia Insectorum*. During these years he published translations of works of travel, works of a religious-philosophical nature which helped ameliorate the antagonism of theologians to studies of nature, and studies of the English language. Death came while studying British *Lepidoptera*. He and his daughters bred many species. His notes

describe the larvae and pupae, for he had realized the importance of these in classification (*Historia Insectorum*, 1710).

The many works, and we note but a few which on every page connote study of the material itself, have come down to us in complete form. They are impressive. Opposed to such masses of evidence the details of his life, his friendships and his connections with science of that day are meagre.

The present author, Charles E. Raven, Doctor of Divinity, has finally built up the intimate picture of John Ray. The style and diction of the present volume will puzzle the usual biologist. Raven explored the archives of many learned societies, museums and libraries for letters and other records of John Ray. He found riches only heretofore suspected. These items he has pieced together and interpreted into a coherent review of John Ray's private life, his relations to other friends and scientists of his time and better yet his methods of work and points of view. John Ray, Naturalist, is a volume with a style and method of exposition seldom found in a scientific treatise. It is a thoroughly documented mass of bits of evidence gathered from all manner of sources. It is the style of an exegesis, a common form of exposition among erudite theologians. It is the form of exposition necessarily imposed by the mass of minute bits of evidence. Only a scholar trained in theological literature of this type could have dug out and used so effectively the scattered facts bearing on Ray's life and works.

We see unfolded the life of a man of tremendous energy who made permanent friendships with everyone whom he contacted. He avoided controversies but never hesitated to write his own views based on direct evidence. He seldom criticised the writings of others but when necessary softened criticism at times by admitting that he himself might be in error on more complete evidence. He was a restless traveler, and at every opportunity was in the field collecting and observing distribution. He dissected animals in the field and made notes on internal anatomy. He was the first on record who studied the food of birds by opening the bird's crop and stomach. Between trips he studied and wrote, at home or in the home of any friend with whom he was staying. His life was a life of friendships, correspondence and continuous study of the material itself. His genius was the ability to recognize and organize valid evidence.—C. H. K.

A REVISION OF THE LIBELLULINE GENUS *ERYTHRODIPLAX* (ODONATA), by DONALD J. BORROR. Pages xv and 286, 6¼ x 9 inches. 1942. Graduate School Studies, Contributions in Zoology and Entomology, No. 4, Biological Series; Published by THE OHIO STATE UNIVERSITY, Columbus, Ohio.

It is very rarely that a taxonomic monograph reaches the high plane of scholarship exemplified by Dr. Borror's Revision of *Erythrodiplax*. To approach so near to perfection demands of the author not only the utmost accuracy both in the study of material and literature, but also that special combination of gifts which go to make the "born taxonomist," viz., a keen sense of form and an aptitude for comparative analysis, coupled with precision and soundness of judgment.

The dragonflies of the genus *Erythrodiplax* are among the most abundant of neotropical Libellulidae and, although they were ably treated by F. Ris (Cat. Coll. Zool. Selys-Longchamps, 1909-1919), much confusion still remained in the nomenclature and taxonomy of the genus, and much material in a number of collections still awaited critical study. Altogether some 8,000 specimens were examined by Dr. Borror in the preparation of this study, more than half of these belonging to the Williamson collection in the Museum of Zoology, University of Michigan, and about one-fourth to collections in Europe, in which many of the types are preserved.

At the time Dr. Borror commenced his study 24 species of *Erythrodiplax* were recognized. One of these, *E. minuscula* of the Southern States, is now reduced to a subspecies of the widely distributed and variable *E. connata*. Other forms, hitherto regarded as having only subspecific status, have been elevated to the rank of species, e.g., *E. naeva*, formerly considered as a race of the well-known *E. berenice*. The total number of species has been increased to 46 with five additional subspecies.

In the introductory sections of the book full consideration is given not only



to morphological features but also to geographic distribution, the affinities of the genus *Erythrodiplax* and the inter-relations of the species.

Special attention is given to the structure of the penis, as it is in this organ that the most definite and, in some cases, the only positive means of identification are to be found. Other useful characters are met with in the hamuli and genital lobes of the males, the venation, color pattern, form of the hind lobe of the prothorax, spines of the hind femora and vulvar laminae of the female. All of these are copiously illustrated.

The genus *Erythrodiplax* is distinctly neotropical, although a few species have entered the United States, one (*E. berenice*) ranging along the Atlantic Seaboard as far as New England, and two others (*E. umbrata* and *E. connata minuscula*) reaching Ohio. The distributional ranges are grouped into five main regions, most of these being further subdivided. The general distribution of the species in these regions and subdivisions is set forth in Table II and further details are illustrated in a series of very fine maps at the end of the book. These distributional data suggest "the Amazon-Guianian region, more specifically the Amazon Basin, as the probable site of the origin of the genus. . . . The greatest speciation, as indicated by the number of endemic species, has occurred in the southeastern part of South America . . ."

Near relations of *Erythrodiplax* are found in both the Old and New Worlds, but the Old World genera, such as *Diplacodes*, *Brachythemis* and *Trithemis*, to which species of *Erythrodiplax* have often been referred by various authors, differ considerably from the latter in the structure of the penis. The New World genera that appear most nearly related to *Erythrodiplax* are *Erythemis*, *Rhodopygia*, *Microthyria* and *Uracis*.

The genus *Erythrodiplax* is divided by Borror into 12 groups, several of these containing one or two species only, while three contain 8 or 9 species each. The inter-relations of these species are clearly set forth in text fig. 1.

The key for the identification of the species is a model of taxonomic analysis and, wherever possible, characters common to males and females have been used. Only a few species have been omitted from the key owing to lack of material and inadequacy of the published descriptions. Group characters are fully described so that a repetition of these is avoided in the specific descriptions, which are concise, except in the matter of venation, in which the variations are given both in actual numbers (veins or cells) and in percentages. The seasonal and distributional data are very fully recorded.

As to illustrations, these leave nothing to be desired. There are 41 plates, and, excluding the last 12, which are distributional maps, there are 420 figures, all of which are of the highest excellence. The first 9 plates are from photographs of wings; the remaining figures are line or (in case of color patterns) stipple drawings. Special mention should be made of five plates (90 figures) of penes. Not only are those of each species illustrated but in many cases several figures are given to show the range of specific variation. The wide-ranging and variable *E. connata*, with its three races, is illustrated by no less than 14 figures of penes alone.

Space forbids the enumeration of all the excellent features of this monograph. Suffice it to say that, with two or three others of its kind, such as Hubbell's Monographic Revision of *Cenikophilus*, it sets a standard in taxonomy which only a few can hope to attain.—E. M. WALKER.

**THE FEEDING APPARATUS OF BITING AND DISEASE-CARRYING FLIES: A WARTIME CONTRIBUTION TO MEDICAL ENTOMOLOGY,**  
by R. E. SNODGRASS. Smithsonian Miscellaneous Collections, Vol. 104,  
No. 1, 51 pages, 125 figures. 1943.

This timely review of the anatomy of the mouthparts of the blood-sucking Diptera covers the following groups: I. Blattidae (for generalized plan of parts); II. Culicidae; III. Psychodidae; IV. Heleidae (punkies); V. Simuliidae; VI. Tabanidae; VII. Rhagionidae; VIII. Asilidae; IX. The Cyclorhapha (general facts); X. Chloropidae; XI. Muscidae and Glossinidae (tsetse flies); XII. Hippoboscidae, and XIII. Streblidae and Nycteribiidae. It is in the usual style of the many papers published by Snodgrass in the series of the Smithsonian Collections.—C. H. K.

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## OBSERVATIONS ON THE LIFE HISTORY OF TRICHODES ORNATUS (COLEOPTERA, CLERIDAE), A LARVAL PREDATOR IN THE NESTS OF BEES AND WASPS

E. G. LINSLEY AND J. W. MACSWAIN,

University of California,  
Berkeley, California

*Trichodes ornatus* Say is the commonest and most widely distributed representative of its genus in Western North America. It occurs in nearly every state west of the Rocky Mountains, as well as in British Columbia and Alberta, and ranges from sea level up to ten thousand feet elevation. However, in spite of these facts, little has been recorded of the biology of this (or any other) North American species except that the adults are pollen feeders and have been reared from the cells of bees and wasps. As yet, the present authors are not able to provide the complete biology of *T. ornatus*, but it is believed that at least a general outline of the life cycle has been obtained and a number of significant facts determined which had not been previously recorded for the genus.

### HISTORICAL BACKGROUND

Our present knowledge of the habits of *Trichodes* has been largely obtained in Europe. It may be briefly summarized as follows:

Apparently *Trichodes apiarius* (Linn.), sometimes referred to as the hive beetle, was the first species of clerid recorded as living in association with bees. As early as 1737, Swammerdam figured the larva, pupa, and adult from a nest of the mason bee, *Megachile muraria* (Fab.). According to most general treatises on apiculture, the species is also supposed to live at the expense of the honeybee, *Apis mellifera* Linn. Mulsant (1864) credits Herbst (1792) and Sturm (1837) with being the first to express this opinion, while Duncan (1840) attributes the statement to Aristotle. The fact that Linnaeus named the species *apiarius* indicates that the belief was prevalent prior to Herbst and Sturm. In any event, although many entomological textbooks record *apiarius* from bee-hives, we have been unable to find any recent verification of this observation in the literature.

*Trichodes alvearius* (Fab.) was also reared at an early date from the nests of bees. This appears to be the species discussed by Reaumur in 1742, although various authors are in disagreement as to the identity of

the form with which he was concerned. Westwood (1839) and subsequent authors have recorded it from the nests of *Osmia* and *Megachile*, Friese (1923) has added *Xylocopa* and *Anthophora* as well as the wasp *Polistes gallicus* (Linn.), and Carpentier (1883) reared it from the cells of *Odynerus spinipes* (Linn.). In addition, Latreille (1804) has recorded it from *Vespa*, and Goreau (1866) from the hives of *Apis*. However, the most instructive account of the habits of this species is that of Maréchal (1933) who studied it as a predator in the cells of *Chelostoma maxillosum* (Linn.).

A third species which has long been known as a bee predator is *Trichodes octopunctatus* (Fab.). Lichtenstein (1877) reared it from the nest of *Megachile rufescens* (Pérez), and Maréchal (1933) from that of *M. pyrenaica* Lep. The latter author also believed that this was the species frequently referred to by Fabre in his classical studies of the biology of bees.

*Trichodes umbellatarum* Oliv. has been studied in some detail by Cros (1908 *et seq.*). He found it living at the expense of *Megachile muraria* (Fab.), *Anthocopa longispina* (Pérez), *Osmia* spp., *Anthophora talaris* Pérez, *A. albigena* Lep., and *Eumenes* sp.

*Trichodes leucopsideus* (Oliv.) has been recorded by Mayet (1894) from the burrows of *Ceratina*.

In addition to those species associated with bees, several *Trichodes* have been noted as predators of the egg pods of locusts. Kunckel d'Herculais (1890 *et seq.*) and subsequent authors have observed *T. amnios* (Fab.) destroying the eggs of the moroccan locust (*Doclostaurus maroccanus* Thunb.) and according to Jackson (1926) and Cros (1929) eggs of this same species are also preyed upon by *T. laminatus* Chev. and *T. x-litterata* Chev. Jazykov (1931), working in Turkestan, noted two additional species of *Trichodes*, one (?*T. turkestanicus* Kr.) in the egg pods of *Ramburiella turcomana* (Fischer) and *Doclostaurus kraussi* Ingenitskii the other (probably *T. spectabilis* Kr.) in those of *Doclostaurus maroccanus* Thunberg.

## DESCRIPTION

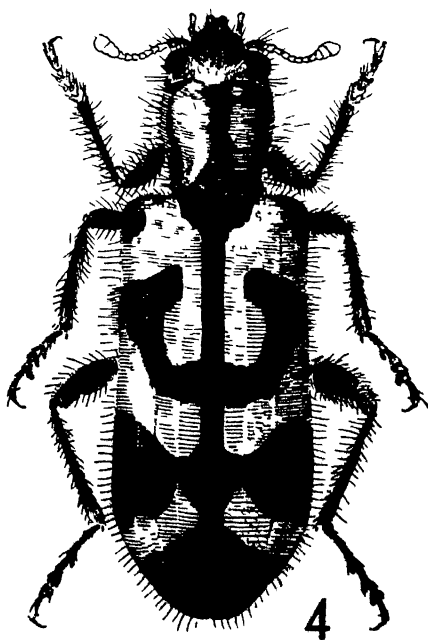
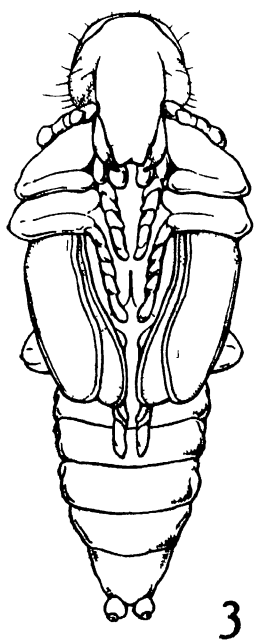
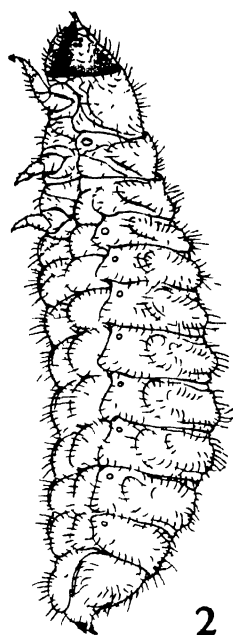
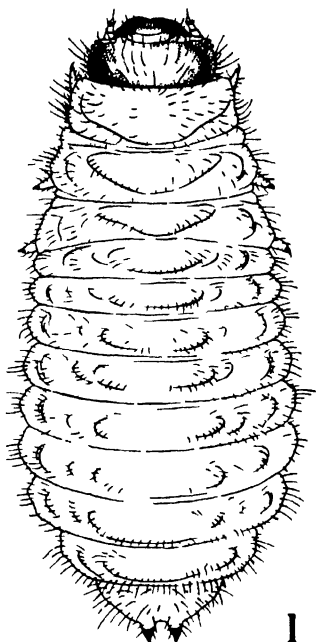
### ADULT

#### Figure 4

*Male*.—Form elongate, moderately slender, sides of elytra widest behind middle, color shining aeneous green, antennae, mouthparts, and anterior and intermediate tarsi pale brownish, elytra dark blue with yellow markings; pubescence long, erect ochraceous. Head large, as wide as or wider than pronotum; surface moderately coarsely but not closely punctate, the punctures larger on vertex; pubescence sparse, long, erect; eyes moderately prominent, anteriorly emarginate, finely faceted; antennae with club broadly triangular. Pronotum about as long as wide, broadly constricted at base, feebly so at apex; surface moderately coarsely, densely punctate, clothed with long, erect hairs; prosternum transversely rugulose; scutellum small, finely,

## EXPLANATION OF PLATE I

*Trichodes ornatus* Say. Figures 1-2. Fifth instar larva. 3. Pupa. 4. Adult.



closely punctate, shining. Elytra more than twice as long as basal width, widest behind middle; surface blue, shining, feebly but closely punctate, clothed with much shorter pubescence than pronotum; yellow pattern consisting of a broad basal band surrounding the humeral umbone and extending back along suture to basal two-fifths; where it is dilated and knob-like; an oblique, sinuate median band extending backward from lateral margin to suture; and an oblique subapical band extending backward from the suture; apices rounded. Legs slender, brassy green, at least the anterior and intermediate tarsi pale brownish. Abdomen brassy green, shining; sternites sparsely punctate, very sparsely clothed with suberect pale hairs; fifth sternite broadly emarginate at apex, sixth sternite longer than fifth. Length, 5–11.5 mm.

*Female*.—Form more robust than male; elytra with yellow pattern more extensive; abdomen with sixth sternite shorter than fifth, largely concealed. Length 7–15 mm.

Varieties: Elytra dark blue, blue, or greenish, elytral bands yellow or faintly orange-yellow, very variable in extent, rarely coalescing over basal two-thirds or reduced to an oblique, oval, post median spot.

Subspecies *tenellus* LeConte: Form more slender with a lesser average length; elytra more coarsely, regularly punctate, bands frequently reddish, broad, median band very oblique. Length 5–8 mm. Distribution: arid regions of southwestern United States and northern Mexico.

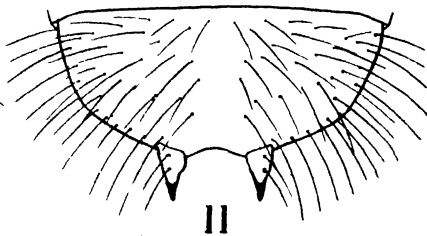
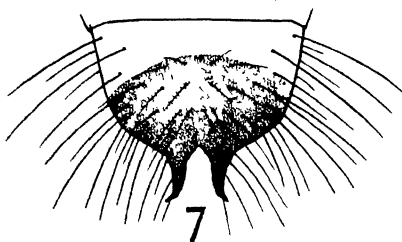
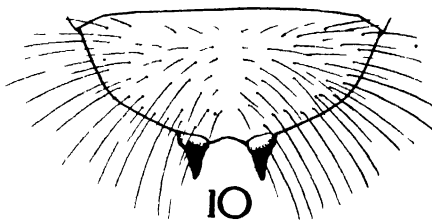
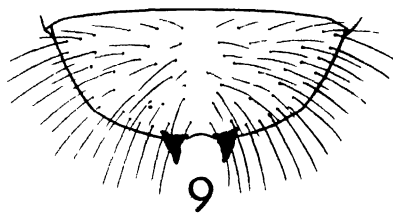
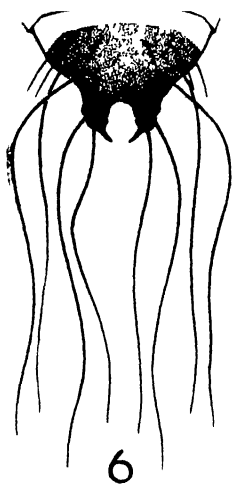
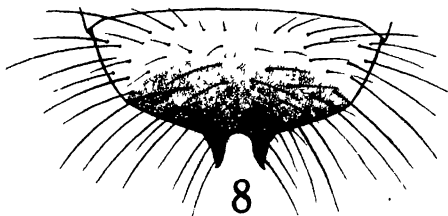
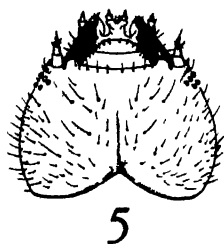
#### EGG

Form elongate, slender, slightly curved, tapering at each end, broadest at middle, a little wider at one end than at the other; color of contents pale orange, becoming bright orange with development, narrow end colorless; chorion smooth, shining, transparent, without ornamentation. Length 1.73 mm.; median breadth 0.46 mm.

#### LARVA

Böving and Champlain (1920) have characterized the mature larva (probably fifth instar) of *T. ornatus* as follows:

"Total length of body, 13 mm.; extreme width, 3 mm.; extreme thickness,  $2\frac{3}{4}$  mm.; anterior width of prothorax,  $2\frac{1}{2}$  mm. Mandibles, epistoma, tip of cerci dark brown; remainder of head capsule, prothoracic shield and other delicately chitinized parts pale cadmium yellow; membranous parts salmon red. Setae thin, long, yellowish. Frons hardly sculptured. Labrum more than twice as wide as long. Mandible from apex to attachment of retractor tendon about two-thirds the length of frons; length to width as 9 to 8; apex does not project over inner corner of mandibular basis; distance between retinaculum and apex of mandible one-third the length of mandibular inner margin; elevation of inner margin between retinaculum and apex slightly convex; at least seven fine mandibular setae. Basal plate of cerci poorly developed. Cerci upright, pointed, conical, slightly curved, from end to attachment less than half as long as frons."



#### EXPLANATION OF PLATE II

*Trichodes ornatus* Say. Figure 5. Head capsule of fifth instar larva. 6. Caudal plate of first instar larva. 7. Same, second instar. 8. Same, third instar. 9. Same, fourth instar. 10. Same, fifth instar. 11. Same, sixth instar. (All drawings to different scales.)

The remaining larval instars have not, however, been differentiated. They may be recognized as follows:

*First Instar* (fig. 6).—Length 2 mm. Form elongate, very slender; color cream to pale salmon pink. Head with longer lateral setae about twice head length; mandibles acute at apex. Caudal plate covering most of ninth abdominal tergite except for a narrow band at base; caudal processes very robust, wrinkled, with a stout spine at apex, setae very long, coarse, about three times as long as caudal plate.

*Second Instar* (fig. 7).—Length 5 mm. Form elongate, moderately slender; color salmon pink to reddish. Head with longer lateral setae about one-fourth head length; mandibles less acute at apex. Caudal plate covering most of ninth abdominal tergite except for a relatively broad, curved band at base; caudal processes long, slender, curved, tapering to an acute tip, longer setae a little more than twice as long as caudal processes.

*Third Instar* (fig. 8).—Length 11–12 mm. Form elongate, moderately robust; color salmon pink to scarlet. Head with longer lateral setae about one-half head length; mandibles moderately obtuse at apex. Caudal plate covering most of ninth abdominal tergite except for a broad, curved band at base; caudal processes long, moderately slender, apex curved, with a very short tooth, longer setae a little more than twice as long as caudal processes.

*Fourth Instar* (fig. 9).—Length 13–14 mm. Form elongate, moderately robust; color salmon pink to scarlet. Head with longer lateral setae about one-half head length; mandibles moderately obtuse at apex. Caudal plate reduced to caudal processes; caudal processes heavily sclerotized, short, obtuse, moderately robust, longer setae less than twice as long as caudal processes.

*Fifth Instar* (figs. 1, 2, 5, 10).—Length 12–13 mm. Form elongate, moderately robust; color salmon pink to scarlet. Head with longer lateral setae about one-third head length; mandibles obtuse at apex. Caudal plate reduced to caudal processes; caudal processes sclerotized nearly to base, short, stout, separated by at least twice basal width, apex moderately acute, longer setae more than twice as long as caudal processes.

*Sixth Instar* (fig. 11).—Length 12–13 mm. Form elongate, moderately slender; color salmon pink to scarlet. Head with longer lateral setae about one-third head length; mandibles obtuse at apex. Caudal plate reduced to caudal processes; caudal processes sclerotized at apex only, short, stout, separated by more than twice basal width, apex moderately acute, longer setae more than twice as long as caudal processes.

## LIFE HISTORY OBSERVATIONS

### ADULTS

The adults of *Trichodes ornatus* (fig. 4) have been taken from March to September and in any one given locality may be found over a period of about two months. After emergence they seek a wide variety of flowers, particularly *Achillea millefolium*, *Asclepias* spp., and various

yellow Compositae. Böving and Champlain (1920) state that the adults are not predaceous but feed solely on pollen. Although pollen is undoubtedly a major item of food, the present writers have observed adults to completely dismember and feed on other living insects (mostly small Coleoptera) and the female to consume the male after copulation. These observations were made in the field and were duplicated in the laboratory. (See also Linsley, 1942.)

Similar observations have been made by de Gaule (1874) who observed *Trichodes alvearius* plunging its mandibles into the abdomen of a hymenopteron; Cros, who recorded attacks by *T. umbellatarum* on beetles and bees; and Portchinsky (1914), who watched a *Trichodes* devour a specimen of *Mylabris*.

Mating takes place upon flowers and the pairs copulate for several minutes, during which time feeding and other activities are discontinued. Females which have previously copulated attempt to dislodge subsequent males by rapid lateral vibrations of the body. Mating is not preceded by preliminary courtship and upon its completion the female may devour the male.

Oviposition occurs on the flower heads frequented by the beetles. The act of oviposition has been observed in the field on *Achillea*, with the female assuming a position on the underside of the floral head and forcing the tip of the abdomen among the flowers to oviposit. The eggs are laid singly, depending for support upon a mucilaginous coating. Sometimes they are deeply imbedded in a single flower. The incubation period of eggs under laboratory conditions (20°–23° C.) varied from 18 to 20 days.

#### LARVAE

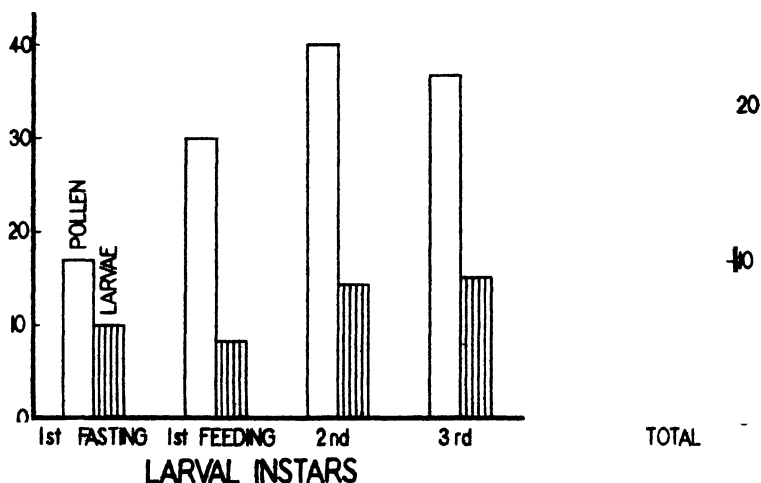
The means of access to the cell of the host bee or wasp was not definitely determined but in any event, having entered the cell, the primary larvae remain for a considerable period of time without feeding. Usually this period is sufficiently long to allow the host to attain the prepupal state. In the laboratory, in the presence of prepupal larvae, this period of fasting varied from 9 to 12 days (mean, 10 days). When ready to begin feeding, each larva makes a small puncture in the body of the host and feeds upon the liquids which exude. In the first instar, from two to five such punctures may be made. During this period growth is rapid but the time from the moment feeding begins until the first molt occurs may vary from 5 to 18 days (mean, 6 days).

In order to study some of the gross reactions of the first instar larvae, eggs were obtained in the field and laboratory and the resultant larvae subjected to various conditions of food and moisture. One group was supplied with a solution of one part honey to one part water mixed with dry pollen and placed in relative humidities of 50 and 75 per cent at temperatures of 20°–23° C. A second group was provided with prepupal larvae of *Anthophora linsleyi* Timb., a species selected because its larva has a relatively tough integument. These series were likewise placed under the same conditions of temperature and humidity. A third group was established with prepupal larvae of *Odynerus blandinus* Sauss., selected because of its soft, thin, flaccid integument. The larvae which were supplied with pollen alone were slow to begin



feeding and subsequent growth and development was greatly retarded (text fig. 1); those provided with *Anthophora* larvae encountered difficulty because the first puncture resulted in almost immediate deterioration of the host through bacterial infection; but those offered larvae of *Odynerus*, apparently found satisfactory food conditions (text fig. 1). However, in all cases, the better results were obtained in a relative humidity of 75 per cent at temperatures of 20°–23° C.

The second instar larva of *Trichodes* continues feeding by a series of punctures and it is during this period that the host larva usually dies. The length of time spent in the second instar varied from 13 to 15 days (mean, 14 days). The third instar is the last larval feeding stage and during this period the larva obtains its maximum growth (this instar required from 12 to 16 days, with a mean of 15 days). When feeding has been completed, the larva attempts to leave the cell in which it has



TEXT FIGURE 1. Comparison of the duration of the three larval feeding instars of *Trichodes ornatus* when reared on pollen and on larvae of *Odynerus blandinus*.

been reared. Thus larvae which have fed on bees nesting in banks excavate pupal cells about a half inch away from the burrows of their host; in twigs they normally construct an elliptical cell apart from the main tunnel of the bee or wasp; and in the hard cells of *Odynerus* and *Dianthidium* they cut their way out and pupate elsewhere or die later as unemerged adults within the cell. In the laboratory, the larvae readily burrow into corks and construct pupal chambers. Shortly after entering the cork, they transform to the fourth instar. In this instar the pupal cell is completed and any cracks are sealed with a dark brown oral secretion. In addition a burrow is made nearly to the surface of the cork, leaving only a thin partition to be broken through by the emerging adult. The winter is passed as a fourth instar larva within this pupal cell and transformation to the fifth instar occurs in spring or early summer. Occasionally an additional (sixth) instar may occur. In such

cases the sixth instar may follow the fifth within a few weeks or in the summer of the second or third year. Pupation requires about twenty days under laboratory conditions.

*Trichodes* larvae can be reared solely on pollen. However, such larvae take about three times as long to complete their growth (text fig. 1) as those fed on bee or wasp larvae under the same conditions of temperature (20°-23° C.) and relative humidity (75%).

#### HOSTS

*Trichodes ornatus* has been taken by the writers from the following aculeate Hymenopterous hosts. Two published records have also been included in order to make the list as complete as possible.

#### Family Megachilidae

*Callanthidium illustre* (Cresson). Mt. Diablo, Contra Costa Co., Calif., December 8, 1940, nesting in sandstone cliff. *Trichodes* larva, having destroyed contents of terminal bee cell, had burrowed into bank for several mm. and constructed its pupal cell.

*Dianthidium consimile* (Ashmead). Palm Springs, Riverside Co., Calif. Two dead adults and two living larvae found in unopened cells two years after they were collected in the field (Davidson, 1896: 25).

*Dianthidium pudicum provancheri* Titus Antioch, Contra Costa Co., Calif., June, 1938, nesting on dry plant stem. One dead adult found in unopened cell eighteen months after it had been brought into the laboratory. Coarsegold, Madera Co., Calif., May 12, 1942. One unemerged adult found in 1941 cell series (Linsley, 1942).

*Dianthidium macswaini* Timberlake. Mt. Diablo, Contra Costa Co., Calif., May 9, 1939, nesting on surface of sandstone boulders. One dead adult and one living fifth instar larva found in unbroken cells of different nests. June 1, 1941, a second instar larva found consuming prepupal bee in same locality.

*Dianthidium* sp. Strawberry, Eldorado Co., Calif., October 31, 1931. *Trichodes* larva left cell and bored into cork of vial; pupa observed Nov. 16, 1933, adult emerged Nov. 26, 1933 (Essig, 1934: 724).

*Megachile brevis onobrychidis* Cockerell. Davis, California, October 10, 1940, nesting in twig of elderberry (*Sambucus*). One fourth or fifth instar larva in cell series of 1940 season (G. E. Bohart).

*Hoplitis productus* (Cresson). Mineralking, Tulare Co., Calif., August 10, 1939, nesting in twigs of elderberry (*Sambucus*). One fifth instar larva found in bee cell. This larva subsequently refused all food and was still alive in May, 1941.

*Hoplitis sambuci* (Titus). Mineralking, Tulare Co., Calif., August 10, 1939, nesting in twigs of elderberry (*Sambucus*). One fifth instar larva in resting cell.

*Hoplitis biscutellae* (Cockerell). Twenty miles east of Indio, Riverside Co., Calif., April 1, 1941, nesting in bank. One immature larva found in a cell provisioned during the 1941 season.

*Anthocopa xerophila* (Cockerell). Ten miles south of Little Lake, Inyo Co., Calif., April 3, 1941, nesting in low bank and utilizing old burrows of *Anthophora linsleyi* Timb. One sixth instar larva found in closed cell. Larva pupated on April 7, 1941, and transformed to adult on April 26, 1941.

*Osmia* (*Nothosmia*) *clarescens* Cockerell. Twenty miles east of Indio, Riverside Co., Calif., April 1, 1941, nesting in bank in old burrows of *Anthophora* n. sp. One fifth instar larva and one freshly transformed pupa.

*Ashmeadiella* n. sp. Mt. Diablo, Contra Costa Co., Calif., December 8, 1940, nesting in old cells of *Odynerus* sp. One dead adult found in unopened cell.

#### Family Ceratinidae

*Ceratina acantha submaritima* Cockerell. Kyburz, Eldorado Co., Calif., July 26, 1941, nesting in stems of elderberry (*Sambucus*). One dead adult in cell series.

Family **Eumenidae**

*Odynerus blandinus* Cresson. Mt. Diablo, Contra Costa Co., Calif., December 8, 1940, nesting in mud cells plastered on rocks. One fourth instar larva found in an unopened cell which had contained a prepupal larva of *Odynerus* (as evidenced by the silken lining of the cell); larval skins found in a cell from which *Trichodes* had emerged. December 24, 1940, same locality, two dead adults and one fifth instar larva found in unbroken cells of different series.

Family **Massaridae**

*Pseudomassaris coquillettii* Rohwer. Mt. Diablo, Contra Costa Co., Calif., December 8, 1940, nesting in mud cells plastered on rock. Third instar larva found opening an escape hole to the surface.

## DISCUSSION

The method by which the larvae of *Trichodes* gain access to the cell of the host bee or wasp was not determined. However, in view of the fact that the eggs are laid on flowers, only two alternative methods suggest themselves. Either the larvae find and enter the cell under their own locomotion or are carried there by the hosts. The former method seems highly improbable because of the relatively few eggs laid by *Trichodes*, the fact that most of the infested nests encountered were widely separated from flowers, and the scattered and secretive nesting habits of many of the commoner hosts. Infested nests were found in dead logs, twigs of living trees and shrubs, hollow stems of annual plants, burrows in the flat ground and in banks, and in cells on the surface of rocks. The only evident common denominator was the fact that the nests were those of bees or wasps. Furthermore, it is apparently necessary for the *Trichodes* larva to gain access to the host cell in that brief interval when it is being provisioned. This is emphasized by the facts that the primary larvae are incapable of boring into a closed cell and that all of the hosts with which *Trichodes* has been found provision their cells during the period when the adult clerids are active.

Variation in the number of larval instars in *Trichodes* parallels similar variation in certain other species of predaceous beetles. Ingram and Douglas (1932) and Horsfall (1941) record five feeding larval instars in two species of *Epicauta*; yet, under certain conditions, two additional non-feeding instars occur. Struble (1941) found that there may be either five or seven larval instars in the ostomatid *Temnochila virescens* (Fab.). However, this same author found only three larval instars, all feeding stages, in *Enoclerus sphageus* (Fab.). Apparently, this represents the normal number of feeding instars in the family Cleridae and the super-numerary instars serve to carry the species over unfavorable conditions.

Plasticity and adaptability in the food habits of *Trichodes* is indicated by the fact that newly hatched larvae deprived of insect food can complete their development on pollen alone. In our experiments such larvae fasted twice as long as those offered prepupae of wasps and when feeding began they required about three times as many days for each larval instar. However, the fact that they can live on pollen is another survival factor in their favor, since the host bee or wasp may die in the egg or as a very young larva. It also probably indicates that there is a close relationship between the nutritive value of pollen and that of insect eggs and of larvae fed on pollen, since many insects may live on either.

## CONCLUSIONS

- (1) *Trichodes ornatus* is normally predaceous in both the adult and larval stages.
- (2) Larval food is normally restricted to the immature stages, especially the prepupae of aculeate Hymenoptera, in particular the bee family Megachilidae. However, in the absence of insect food the larvae can complete their development on pollen.
- (3) Larval development includes three feeding and two non-feeding instars. Under certain conditions a sixth instar may occur.
- (4) The life cycle varies from a single year to three or more years.

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THE INTERNAL ANATOMY OF *DERMACENTOR ANDERSONI* STILES, by J. R. DOUGLAS, 1943. University of California Publications in Entomology 7(10): 207-272, pls. 8-26, and 7 text figs. UNIVERSITY OF CALIFORNIA PRESS, Berkeley and Los Angeles. Paper bound. Price \$1.25.

For years we have needed studies of the internal anatomy of mites and ticks. Few outside the larger Ixoidae are easily studied. Our experience has been that the average student on opening a mite or tick and after seeing the complexity of branching and convoluted parts gives up and works on some insect with relatively simple internal parts. One has to admit he shows judgment as far as easy success is concerned.

Douglas has stuck it out and has given us some good figures of internal anatomy in a *Dermacentor*, one of the larger forms. His drawings are more satisfying than his plates of photomicrographs. Perhaps his venture will lead the way for others in this important group of Arthropods. The students of parasitology should learn what is inside a tick.—C. H. K.

# A REVISED CLASSIFICATION OF THE REDUVIOIDEA WITH A NEW SUBFAMILY FROM SOUTH AMERICA

(Hemiptera)

ROBERT L. USINGER,  
University of California, Davis

The classification of the Reduvioid bugs has long remained in an unsettled state. Stål's masterful classification (1872, 1873) is still our best and only reference for subfamilies and genera and Reuter's general classification of the Heteroptera (1910) remains as the standard for higher groups. Evidence from the male genitalia (Singh-Pruthi, 1925) and from the mandibular levers (Ekblom, 1929) has since shown clearly that the semi-aquatic Mesoveliidae and Hebridae belong elsewhere. Despite a truly remarkable diversity, the group as thus restricted is apparently monophyletic.

The discovery of an apparently new type of Reduvioid bug from Paraguay made it necessary to review all of the principal groups of Reduvioidea. Since many uncorrected errors were found in the literature, since so much new anatomical information has become available in recent years, and since several significant annectant types have come to light, the time appears to be right for an analysis of the group as a whole.

With the generous co-operation of H. G. Barber, W. E. China, A. da Costa Lima, C. J. Drake, H. M. Harris, and F. C. Lutz, I was able to study representatives of all of the subfamilies except the unique Central American Chryxinae. In most cases specimens were softened in KOH and studied under high magnification with transmitted light. Basic wing venation was studied by examining the tracheae of recently molted, teneral adults, the hemelytra and wings being mounted in glycerin jelly.

## FAMILY CHARACTERS

In their recent analysis of the Cimicoid families, China and Myers (1929) found that the structural differences separating long established families broke down. Exceptions were found in the form of so-called annectant types. Phylogenetically, this is not surprising and we may expect to find even more relics of ancestral groups as entomological exploration becomes more comprehensive and exhaustive. Recent studies indicate that a similar condition exists in the Gerroidea and the present study shows clearly the arbitrary nature of the lines separating families in the Reduvioidea.

*Scent Glands.*—In 1910 Reuter gave as a primary character of the Reduviidae, "*Nymphae orificio glandularum dorsalium ad marginem anticum segmentorum 4-6 posito.*" Readio (1927) and Brindley (1930) have shown that this condition varies. Although nymphs of many groups were available during the present study, it was found that the scent gland openings persist, though the actual glands appear to be

reduced, in the adult stage. The number and position of these scent gland openings in the various Reduvioid groups is as follows: *Enicocephalidae*—one opening in the middle of the fourth segment; *Nabinae*—three openings at front margins of fourth, fifth and sixth segments; *Phymatidae*—two openings at front margins of fifth and sixth segments. The Reduviid subfamilies differ strikingly in number and arrangement of scent gland openings. The primitive condition, e. g., a complete series of three openings as described above by Reuter, was found in the *Harpactocorinae*, *Apiomerinae*, *Piratinae*, *Vesciinae*, *Cetherinae*, *Reduviinae*, *Microtominae*, *Bactrodinae* and *Tribelocephalinae*. Openings were found only on the fifth and sixth segments in the *Ectrichodiinae* and *Holoptilinae*, on the fourth and fifth segments in the *Stenopodinae* and *Phimophorinae*, and only on the fourth segment in the *Elasmocorinae*. Groups which lacked this series of scent openings entirely are the *Emesinae*, *Saicinae* and *Triatominae*.

In the *Triatominae* Brindley (1930) observed an additional pair of organs, "in the first abdominal segment of the adult insect, one on either side close under the tergite. . . . Each opens by a short duct which leads to an orifice just behind the upper posterior angle of the metathoracic epimeron."

The metathoracic scent glands of bugs are usually well developed and provided with distinct openings and rather elaborate evaporating areas laterally on the metasternum and pleura between the middle and hind coxae. These ostiolar canals are visible in the Nabid subfamilies *Nabinae*, *Arachnocorinae*, *Prostemminae*, and *Gorpinae*. They are not seen in other Reduvioidea, however, and Brindley (1930) has shown, again in the *Triatominae*, that the "stink-gland passes laterally into a groove which runs along the internal face of the emarginated edge of the metacoxal cavity . . . and communicates with the exterior by a small pore." Brindley adds that "the *Emesinae* lack scent glands altogether," and remarks that "the *Nabidae* and *Reduviidae* are generally held to be related, but the scent apparatus, as far as it is known, has nothing in common." I have found the ostioles to be concealed in the Nabid subfamilies *Pachynominae* and *Carthasinae* so it seems likely that the differences noted by Brindley are less fundamental than she supposed.

*Venation*.—The fundamental principles of heteropterous venation were established by Comstock and Needham (1898), and modified by Handlirsch (1908), Tillyard (1926), Tanaka (1926) and Hoke (1926). China and Myers followed this system in 1929 but Usinger (1932) in the *Enicocephalidae* and da Costa Lima (1940) and Mazza and Jörg (1940), working mainly with *Triatomas*, fell into error. It now appears certain that the anterior vein of the hemelytron in most Heteroptera is the subcosta. The radius and media are more or less coalesced at least basally. The cubitus frequently branches and may enclose one or more cells along its course. The anal veins arise behind the claval suture and, inexplicably, cross over to join the cubitus in many cases. In the Reduvioidea this basic pattern is shifted outward or forward beyond the corium in such a way that the homology of the veins is difficult to determine without recourse to the tracheae which precede the veins.



Fig. 1A shows the course of the tracheae (solid lines) and the venation (stippled) of *Triatoma heidemanni* Neiva. The distinction between clavus, corium, and membrane is scarcely indicated in the drawing but is well marked in the specimen. In general, the Nabids show most distinctly a coriaceous clavus and corium, and a hyaline membrane, the Phymatids have the exposed portions of the coria leathery, the Reduviids vary from well differentiated types such as the Microtominae to the entirely membranous Emesinae, and the Enicocephalids have entirely membranous hemelytra.

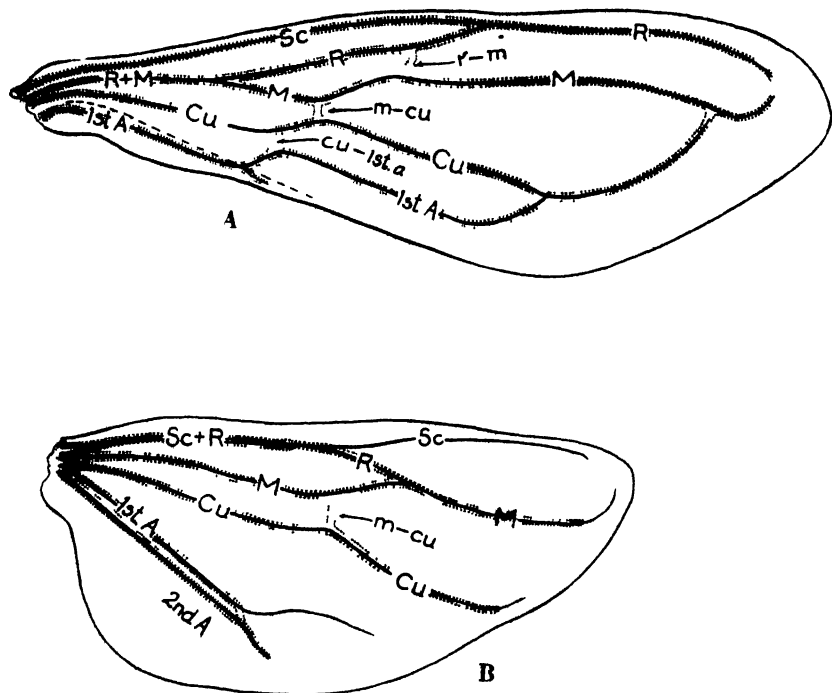


FIGURE 1. Tracheation (solid lines) and venation (dotted lines) of *Triatoma heidemanni* Neiva. A, hemelytron; B, wing.

The typical Reduviid membrane has two or three large cells, bounded by veins R, M, Cu, and 1st A with at least two of these usually closed before the apical margin of the wing. A radial cell is usually formed by the branching of R+M in the corium and a cubital cell is formed by a cross vein connecting Cu and 1st A near the margin between corium and membrane in the Stenopodinae, Apiomerinae, and Harpactocorinae.

The metathoracic wings of the Heteroptera likewise start with a subcostal vein along the anterior margin. In *Triatoma* (fig. 1B) it will be seen that the radius is coalesced with Sc on its basal half. The media is separate to beyond the middle and then approaches and surpasses R; Cu is separate throughout its length but is joined to M by a cross vein.

The basal portion of M before this cross-vein is the so-called hamus. The degree of development of this vein is a valuable criterion for the separation of higher categories in the Heteroptera. The hamus is complete in most Reduvioidea, or at least projects backward for half the distance to base of wing. It is frequently obsolete at the base. The hamus is entirely absent in the Nabid subfamilies Pachynominae, and Arachnocorinae, in the Enicocephalidae, and in the Reduviid subfamilies Holoptilinae and Elasmocorinae.

**Genitalia.**—Singh-Pruthi (1925) found that the male genitalia of Heteroptera fall into two principal types, the Reduviid type and the Pentatomid type. Within the Reduvioidea he studied only twelve of the twenty-eight distinctive types considered in the present paper. A special study of the remaining types may be expected to throw additional light on the interrelationships of Reduvioid types. However, as pointed out by China (1933), too much significance should not be attached to this one set of characters. The close association of the Phymatidae as a subfamily of the Reduviidae is in accord with some other morphological evidence but the complete separation of the Microtominae as a separate family is not supported by the other characters analyzed in this paper. Moreover, the genitalia of the annectent Nabid subfamilies may be expected to bridge the gap which Singh-Pruthi suggests as separating the Nabidae from the Reduviidae.

A striking difference was long ago noticed in the structure of the terminal abdominal segments of the female Pachynominae. Although possessing distinct valvifers and valvulae (terminology according to Snodgrass, 1933), these structures are not developed into an ovipositor suitable for insertion of eggs into plant tissue. Likewise, the seventh sternite is not deeply cleft. This is in contrast to all other Nabids except spider-web bugs of the subfamily Arachnocorinae. The reduced ovipositor is a characteristic feature of all Enicocephalidae, Phymatidae, and Reduviidae.

**Eggs.**—Reuter, in his classification of 1910, attached great importance to the type of eggs in each of the higher groups of Heteroptera. It now becomes apparent that this, like all other characters, may or may not be significant, depending upon the circumstances and upon other supporting characters. Certainly we should expect those Nabids with a reduced ovipositor to lay very different eggs than those with the ability to insert eggs into plant tissue. Unfortunately we know the eggs of only a few Reduvioid types. *Nabis* and *Prostemma* eggs (Michalk, 1935) are, of course, unique in that they are inserted in leaves or stems of plants, and they have assumed the shape characteristic of most deeply implanted types. On the other hand, all Reduvioidea with reduced ovipositor for which information is available, lay dispersed or agglutinated eggs. Readio (1927) has studied eggs of the principal Reduviid types. The Emesinae have elongate, spindle-like eggs with numerous longitudinal folds, the Apiomerinae and Harpactocorinae have vertically agglutinated eggs that may be laid in sticky masses or may be laid individually. These eggs are unique in possessing an enlarged rim forming a head at the micropylar end. An elaborate lid concealed within and is forced out during eclosion. The eggs of Piratinae and apparently also of Stenopodinae have a fringe of long,

slender processes arising from the rim and surrounding the cap at the micropylar end. The Triatominae and Reduviinae have very simple eggs without elaborate circum-micropylar processes and without an enlarged cap region. Special features are confined to details in sculpturing of the chorion and cap (Galliard, 1935). Eggs of the Holoptilinae (Kirkaldy, 1911) present no special features although the cap is relatively large in diameter and has a small rounded knob at the middle.

*Antennae*.—Most Heteroptera have four-segmented antennae and this is the basic number in the Reduvidae. The intercalary knob-like segments of the Enicocephalidae are usually disregarded but become important when, as in certain Prostemmae and Pachynominae, the intercalary segment between the first and second segments becomes nearly as long as the first segment. Still more remarkable is the pseudo-segmentation of the second segment in Microtominae. The number of pseudosegments varies from about 8 in *Homalocoris* to 28 in *Microtomus*.

*Rostrum*.—The heteropterous rostrum was once considered to be sharply three-segmented or four-segmented but China and Myers (1929) and many others have shown that the basic number of segments is four. The three-segmented condition results from a more or less complete reduction of the first segment. Among the Reduvidae the rostrum is clearly four-segmented in the Nabidae (*Scotomedes* Stål?) and in the Enicocephalidae (Reuter's statement, 1910, "*Rostrum triarticulatum*" is an error of observation; see Usinger, 1932). These are the groups which lack a longitudinal, cross-striated, prosternal stridulatory groove. This groove is distinct in the Phymatidae and in the Reduviidae and has been selected as the most reliable guide for the separation of these groups because it is so constant and because the line thus drawn corresponds to the traditional limits of these families. The correlation between stridulatory sulcus and short stout beak is apparently a fundamental one, involving the shortening and strengthening of this otherwise exclusively rapacious, food gathering organ.

*Ocelli*.—The presence or absence of ocelli has long been considered as a reliable subfamily character and it is certainly true that ocelli are always absent in the Reduviid subfamilies Emesinae, Saicinae, Chryxinae, Tribelocephalinae, and Vesciinae. However, the ocelli are reduced or absent in some Reduviinae and Ectrichodiinae, especially those with reduced hemelytra. Some species of the genus *Nabis* lack ocelli as do all Carthasinae and all species of *Pachynomus*.

*Tarsi*.—The primitive number of tarsal segments in the Heteroptera is three and most Reduvidae retain this original segmentation. The tarsi are only two-segmented in the Elasmocorinae and are one-segmented in the Carthasinae. Elsewhere the number becomes variable, there being occasional species with two-segmented tarsi in the Reduviinae and occasional species with one-segmented tarsi in the Enicocephalidae.

*Tibial structures*.—The so-called *spongy fossae* of some Reduvioid groups serve as clinging organs for holding prey and perhaps also for holding a position on the substrate. As nearly as could be observed on *Rasafus*, these structures act as suction cups. They are always present on the front and middle tibiae in some subfamilies and always absent in others. Unfortunately they occur sporadically in the Reduviinae and

in the genus *Nabis* so they can scarcely be considered as fundamental characters for the separation of subfamilies.

Special characteristics such as the bifid or trifid scutellar apices in Ectrichodiinae and Microtominae, the prominent antenniferous tubercles of the Salyavatinae and Sphaeridopinae, the prolonged tibial apices of the Vesciinae, and many others, are modifications or specializations of pre-existing structures that must be evaluated individually.

An entirely unique structure is the trichome of the Holoptilinae, a remarkable process containing a special gland at the base of the abdominal venter. The secretions are said to attract and then stupefy ants which are thus lured to their destruction.

## TAXONOMY

### Superfamily Reduvidae Reuter

**Reduvidae** Reuter, 1910, Acta Soc. Sci. Fenn., 37, No. 3: 72.

Meso- and metasterna simple. Posterior coxae rotatory. Claws without arolia. Abdominal spiracles 2-7 ventral. Hemelytra without a cuneus. Abdominal trichobothria (Tullgren, 1918) absent. Eggs with a distinct micropylar cap and without an egg burster. Male genitalia symmetrical, the basal plates rod-like and fused and the aedeagus lacking a distinct conjunctiva and vesica.

The interrelationships of the Reduvioid families and subfamilies are shown in fig. 2. We may start with a generalized Nabid-like ancestor with 4-segmented rostrum, 4-segmented antennae, distinct ocelli, three abdominal scent gland openings, a basic venation essentially as in fig. 1, and with none of the specialized features detailed in the chart. Then the scent gland openings became concealed independently in the Enicocephalidae, in the Nabid subfamilies Pachynominae and Carthasinae and in the Phymatidae and Reduviidae. A well developed ovipositor may have been present in the ancestral type, in which case it became reduced independently in the Enicocephalidae, in the Nabid subfamilies Pachynominae and Arachnocorinae, and in the Reduviidae and Phymatidae. The hamus followed a similar but more sporadic course, disappearing in the Enicocephalidae, in the Nabid subfamilies Pachynominae and Arachnocorinae, and in the Reduviid subfamilies Elasmocorinae and Holoptilinae. The entirely membranous hemelytra with their specialized branching of vein Cu and the strikingly bilobed head set the Enicocephalidae apart very early but these characters are scarcely more unique than those of the Pachynominae, Arachnocorinae, and Carthasinae so a separate phalanx, Enicocephaliformes (Reuter, 1910) does not seem warranted. Actually the Pachynominae, at least, might justifiably be raised to family rank but such a move should be based upon a more thorough morphological investigation than is possible at present.

The Reduviiformes (Reuter, 1910) became specialized with a stridulatory sulcus and a short, stout, apparently three-segmented beak. The Phymatidae then separated off with the enormous development of the front femora and with the tibiae reduced to curved clasping organs. Also the seemingly trivial matter of an enlarged apical antennal segment

appeared and remains constant to this day. Otherwise the Phymatidae fall well within the remarkable range of variation of the Reduviidae, actually being less peculiar than such groups as the Microtominae, with entirely unique male genitalia and the Holoptilinae and Elasmocorinae, both lacking a hamus and the former possessing a trichome while the latter has only three simple veins in the membrane.

In general, adjacent subfamilies in the phylogenetic key (fig. 2) show more characters in common, though such instances have doubtless resulted from independent, though parallel development in cases where the subfamily is derived directly from the common Reduviid stem. Thus the bucculae of the Phimophorinae and to a less extent of the Tribelocephalinae are suggestive of Phymatid bucculae but close relationship is not supported by other characters. The absence of a hamus in the Elasmocorinae and Holoptilinae and the bifid scutellar apices of the Ectrichodiinae and Microtominae are similar fortuitous parallelisms. The Chryxinae is known to me only by description. It is included where Champion (1898) placed it but may not be so closely related to the Saicinae and Emesinae as indicated on the chart. Since Stål's treatment of the Acanthaspidinae (=Reduviinae, *s. lat.*), there has been a continual culling out of peculiar types that Stål lumped together in his rather unnatural group. Jeannel (1919) first separated out the Cetherinae and Triatominae as tribes, Fracker and Bruner (1924) elevated the genus *Vescia* to subfamily rank and Pinto (1926 and 1927) erected separate families of *Sphaeridops* and for the Triatomas. Unfortunately, the family name Triatomidae has found extensive use in parasitological literature but there is absolutely no foundation for such a status, no characters were given by Pinto to separate it from such Reduviinae as *Physoderes*, and hemipterists have not generally accepted the name. To accept the family Triatomidae would require the elevation of twenty-three other subfamilies to family rank.

The subfamily Reduviinae is still composite and will require further subdivision. For example, Mr. China writes that "the group of genera—*Durganda* A. & S., *Staliastes* Kirk., *Apechthia* Reuter, and *Sminthocoris* Distant" with "extremely flattened body, widely separated coxae, etc. . . have, of course, been placed in the Acanthaspinae but deserved a distinct subfamily." Similarly, the genus *Physoderes*, with a long, cylindrical head and Triatoma-like rostrum, may require a separate subfamily although relationship is suggested to *Stachyogenys* Stål and *Sphedanocoris* Stål. Related to these are the peculiar American genera *Nalata* Stål and *Microlestria* Stål, groups with similar setigerous tubercles and, in some cases, with two segmented tarsi and hemelytral venation suggestive of the Chryxinae.

The Cetherinae may not be as homogeneous as da Costa Lima (1940) assumes, for the American *Caridomma* Bergr. (= *Macrophthalmus* Lap., *Macrops* Burm. and *Sorglana* Kirk.) differ greatly from the African *Cethera* A. and S., having a finely lamellate and spirally twisted projection on either side between the metathorax and abdomen. *Caridomma* has three abdominal scent gland openings while Javanese specimens of the genus *Inara* Stål, which I have studied, have scent glands only on the fourth and fifth segments. *Inara* has been placed in the Reduviinae but the head is short and broad and it may prove to belong with the old world Cetherinae.

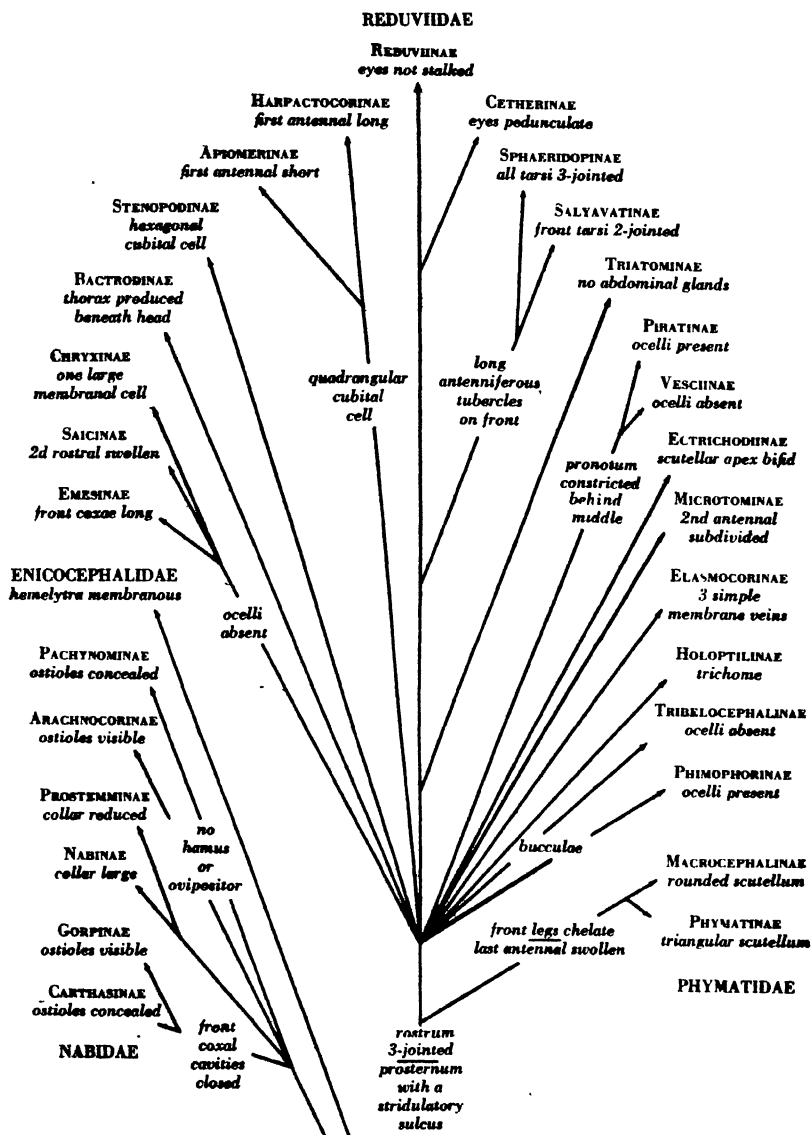


FIGURE 2. Phylogenetic key to the families and subfamilies of Reduvidae.

The Harpactocorinae fall into at least two natural groups, the Harpactocorini (Stål) having a tubercle or fold on either side on the mesopleura at the hind angles of the propleura. These tubercles are lacking in the Zelini (A. & S.). A third tribe, Rhaphidosomini, was proposed by Jeannel (1919) to include several African genera with long slender body form and with the anterior coxal cavities closed behind. I do not know this group. The apterous genera of *Rhaphidosomini* could not be placed by means of the present keys and chart.

The subfamily Tribelocephalinae is difficult to characterize because of the remarkable mimetic genera *Afrodecius* Jeannel (1919), *Apocaucus* Distant (1910), and *Gastrogyrus* Bergroth (1921). Although I have not studied specimens of these, the descriptions and illustration show little relationship to *Opisthoplatys* Westw. and *Tribelocephala* Stål. A careful study may necessitate the separation of these unique genera from the otherwise compact Tribelocephalinae.

In the Nabidae the genus *Arachnocoris* is again raised to its former subfamily status (Reuter, 1890) despite Reuter's subsequent remarks (1908) because the absence of a hamus and the reduced ovipositor (apparently ignored by Reuter) are deemed worthy of subfamily rank. The subfamily Carthasinae (Blatchley, 1926) was proposed as a subfamily of the Reduviidae. Harris (1928) correctly moved this back to the Nabidae where Champion originally placed it. Subfamily status is certainly warranted, however, because of the closed coxal cavities, one-segmented tarsi and flap-like tibial fossae and because of the *Pachynomus*-like, concealed metathoracic ostioles. *Neogorpis* Barber is superficially quite similar to *Carthisis* Champ., but has three-segmented tarsi, lacks the tibial flaps and has conspicuous methathoracic ostioles. Together with *Gorpsis*, it may be separated from the Nabinae by the closed front coxal cavities.

The subfamily Aenictopechinae Usinger (1932) has been suppressed because the type of one of the included genera, e. g., *Gamostolus* Bergr., has recently been loaned by Dr. Drake and proves to be nothing more than a specialized relative of *Enicocephalus*. *Aenictopechys* Breddin thus stands alone and is less peculiar than some other types recently received from the Oriental Region. The Enicocephalidae may eventually be divisible into subfamilies but this must await a monograph of the group which is now approaching completion.

#### KEY TO THE FAMILIES AND SUBFAMILIES OF REDUVIOIDEA

1. Rostrum apparently four-segmented; prosternum without a longitudinal, cross-striated stridulatory groove. . . . . 2  
    Rostrum apparently three-segmented, its tip fitting into a longitudinal, cross-striated prosternal stridulatory groove. . . . . 8
2. Hemelytra entirely membranous, not divided into clavus, corium, and membrane; head distinctly bilobed. . . . . **ENICOCEPHALIDAE**  
    Clavus, corium, and membrane distinct in macropterous forms; head not distinctly bilobed. **NABIDAE**. . . . . 3
3. Methathoracic scent gland ostioles not visible between middle and hind coxae. . . . . 4  
    Metathoracic scent gland ostioles distinct with well developed, transverse canals between middle and hind coxae. . . . . 5
4. Front coxal cavities open behind; antennae five-segmented; tarsi three-segmented; ovipositor reduced. . . . . **Pachynominae**  
    Front coxal cavities closed behind; antennae four-segmented; tarsi one-segmented; ovipositor well developed, the seventh sternite cleft. . **Carthasinae**

5. Abdomen narrowed at base; ovipositor reduced; hamus absent. **Arachnocorinae**  
Abdomen broad at base; ovipositor well developed, the seventh sternite cleft; hamus present. . . . . 6
6. Front coxal cavities closed behind. . . . . **Gorpinae**  
Front coxal cavities open behind. . . . . 7
7. Pronotal collar reduced; clavus narrowed posteriorly, the commissure shorter than scutellum. . . . . **Prostemminae**  
Pronotal collar broad and distinct; clavus broadened posteriorly, the commissure longer than scutellum. . . . . **Nabinae**
8. Apical antennal segments long and incrassate; front femora dilated apically, the tibiae chelate. **PHYMATIDAE**. . . . . 9  
Apical antennal segments not thicker than the remaining segments; front femora not tremendously dilated. **REDUVIIDAE**. . . . . 10
9. Scutellum large, rounded apically; sides of head and propleura not grooved for the reception of the antennae. . . . . **Macrocephalinae**  
Scutellum small, triangular; sides of head and propleura grooved for the reception of the antennae at rest. . . . . **Phymatinae**
10. Membrane with three simple veins; hamus absent; body extremely flattened. . . . . **Elasmocorinae**  
Membrane with one or more closed cells. . . . . 11
11. Base of abdomen produced towards meta-sternum to form a trichome; last two antennal segments each inserted before apex of preceding segment; hamus absent. . . . . **Holoptlinae**  
Base of abdomen without a trichome; last two antennal segments inserted at apices of preceding segments. . . . . 12
12. Under surface of head moderately to strongly produced on either side throughout its length, forming a more or less distinct rostral groove. . . . . 13  
Under surface of head without a buccal groove. . . . . 14
13. Ocelli absent; apical three antennal segments usually slender; body usually clothed with a dense tomentum. . . . . **Tribelocephalinae**  
Ocelli present; apical three antennal segments not long and slender; body without a dense vestiture of apically curved hairs. . . . . **Phimophorinae**
14. Anterior coxae elongated, usually at least four times longer than wide and usually extending well beyond apex of head; long slender insects with hemelytra almost entirely membranous; front legs raptorial. . . . . 15  
Anterior coxae shorter, usually less than twice as long as broad and not extending beyond apex of head; usually broader insects with well differentiated clavus, corium, and membrane and without greatly modified front legs. . . . . 16
15. Ocelli and abdominal scent gland openings absent. . . . . **Emesinae**  
Ocelli and three abdominal scent gland openings present. . . . . **Bactrodinae**
16. Pronotum constricted behind the middle. . . . . 17  
Pronotum constricted at or near the middle. . . . . 18
17. Ocelli present; front and middle tibiae not curved apically, provided with spongy fossae at their apices. . . . . **Piratinae**  
Ocelli absent; front tibiae curved apically and produced beyond insertion of tarsi as a stout spine; spongy fossae absent. . . . . **Vesicinae**
18. Ocelli always absent. . . . . 19  
Ocelli present except in rare brachypterous forms. . . . . 20
19. Second rostral segment swollen at base; membrane with at least two closed cells. . . . . **Saicinae**  
Second rostral segment not swollen at base; membrane with only a single large cell. . . . . **Chryzinae**
20. Cubitus branching to form an additional four- to six-angled cell between corium and membrane. . . . . 21  
Cubitus simple, not forming such an extra cell. . . . . 23
21. Cubital cell usually hexagonal; first antennal segment stout, porrect; abdomen with only two scent glands. . . . . **Stenopodinae**  
Cubital cell usually quadrangular; first antennal segment usually relatively slender; abdomen with three scent glands. . . . . 22
22. First antennal segment short, but little longer than head; ocelli often farther apart than eyes; claws simple. . . . . **Apicomarinae**  
First antennal segment usually longer than head; ocelli usually closer together than eyes; claws dentate or appendiculate. . . . . **Harpactocorinae**



23. Second antennal segment subdivided into from eight to thirty pseudo-segments; eyes located posteriorly, the ocelli placed between them, *Microtominae*  
 Second antennal segment not subdivided; ocelli located behind the compound eyes.....24
24. Head rarely transversely constricted behind the eyes, the ocelli usually located on oblique elevations at postero-lateral angles of the long, cylindrical head; dorsal abdominal scent gland openings absent. *Triatominae*  
 Head transversely constricted behind the eyes; abdominal scent glands present.....25
25. Eyes strongly pedunculate..... *Cetherinae*  
 Eyes not stalked or pedunculate.....26
26. Antennae inserted anteriorly or, more commonly, laterally but not on long, anteriorly projecting tubercles..... *Reduviinae*  
 Antennae inserted on prominent, anteriorly projecting tubercles at front of head.....27
27. Front tarsi two-segmented; middle and hind tarsi three-segmented, *Salyavatinae*  
 All tarsi three-segmented..... *Sphaeridopinae*

#### Subfamily *Elasmocorinae* Usinger, new subfamily

Body strongly flattened. Head transverse, divided by an arcuate transverse impression behind eyes. Ocelli distinct, located near lateral margins of posterior lobe very close to eyes. Basal antennal segment thickest, short; second long, cylindrical; third and fourth very slender. Rostrum very short, broad, curved. Pronotum transversely impressed near the middle, pro- and mesothoracic acetabula projecting laterally, visible from above. Scutellum short, broad, unarmed. Thoracic sterna entirely flattened into a broad, continuous, plate-like surface, the coxae very widely separated. Prosternal stridulatory groove short but distinct. Coxae short, globular, trochanters distinct, tarsi two-segmented. Front legs not of the raptorial type, the tibiae simple. Hemelytra with simple venation, R+M unbranched in the corium, Cu simple and unbranched, the membrane with three simple veins which do not form cells and do not reach apical margin. Abdomen with a single scent gland opening on front margin of fourth tergite.

Type genus: *Elasmocoris* Usinger, new genus.

The *Elasmocorinae* may possibly be related to the Brazilian *Elasmodema erichsoni* Stål (1858) which was described as a Reduviid but was said to be intermediate between the Aradidae and Reduviidae. Unfortunately Stål completely ignored this anomalous genus in his monumental *Enumeratio Hemipterorum*, so later workers have known it only by the rather inadequate original description. Stål mentions the flattened body and three-veined membrane but says that the ocelli are absent and does not mention the number of tarsal segments nor the setigerous tubercles. Other differences will doubtless become apparent when the type of *Elasmodema* is examined and it may even be that the two genera are not closely related at all. Under the circumstances, the new subfamily has been given the name of the Paraguayan bug described in this paper.

Lethierry and Severin (1896) placed *Elasmodema* with the entirely unrelated *Joppeicus* Puton (1881) as a subfamily Elasmodemidae of the Aradidae. *Joppeicus* has since been moved to the Lygaeidae (Bergroth,

1898), thence as a separate family Joppeicidae to the Aradoideae (Reuter, 1910) and recently back to the Lygaeoidea (China, 1933). Da Costa Lima (1940) erroneously synonymized the Elasmodemidae with the Joppeicidae and placed the family in the Reduviidae.

Another perplexing type is the new genus *Platymicrus* described by Bergroth (1903) from Africa. Of *Platymicrus* Bergroth says, "*Genus Reduviinarum in tota subfamilia notis omnibus certe maxime insigne, forte optime prope Opinum Lap., Stal collocandum (Generi Heteropinus Bredd. nuperrime descripto magis affine est), habitu generi americano anomalo et ambiguo mihi ignoto Elasmodema Stal versimiliter sat simile.*"

#### Genus *Elasmocoris* Usinger, new genus

Head, thorax and appendages beset with numerous setigerous tubercles. Head only briefly produced between short, stout antenniferous tubercles. Eyes small, connected by an arcuate transverse impression in the otherwise flat upper surface.

Pronotum transversely arcuately impressed near the middle, and longitudinally impressed throughout its length at middle; feebly carinate and straight along lateral margins. Prothoracic acetabula strongly and mesothoracic acetabula slightly visible from above, the coxae inserted ventro-laterally because of the extremely flattened and uninterrupted sternal plates. Scutellum short, three times as broad as long, rounded and unarmed at apex. Thoracic sternum entirely flattened into a continuous plate-like surface, the prosternum relatively narrow, about half as wide as meso- and metasterna between the front coxae; still more narrowed in front of fore coxae and provided with a short, broad, oblique, transversely striated groove at anterior margin. Meso- and metasterna not distinctly separated, fused into a single, subquadrate plate without distinct carinae or sutures. Mesothoracic legs inserted at postero-lateral corners. Femora scarcely longer than tibiae, the front femora three and one-half times as long as wide near base, middle and hind femora less strongly incrassate; tibiae more slender, tapering slightly apically, the front tibiae briefly produced at inner apices as rounded lobes beyond insertions of tarsi. Tibiae feebly longitudinally impressed above and beneath between rows of setigerous tubercles. Tarsi two-segmented, the first segment one-fourth as long as second. Claws prominent, simple. Hemelytra complete, reaching nearly to tip of abdomen and exposing the connexivum quite broadly; clavus distinct, narrow, tapering apically; corium extending beyond middle of hemelytron laterally, vein R+M strongly elevated, unbranched, Cu less conspicuous and shorter, obsolete at base. Membrane large, distinctly delimited from corium with an anterior vein (M) which is obsolete at base, a long vein at middle which extends, unbranched, nearly to apex and appears to be a continuation of the corial R+M, though by homology with other Reduvioid types it must be Cu, and a third posterior vein which reaches nearly to apex and which is assumed to be the 1st Anal vein though it arises beyond the junction of Cu with the apical corial margin. Wing venation simple, the so-called discal cell and vena decurrens (China and Myers, 1929) distinct and the hamus absent.

Abdomen flattened, the surface smooth or finely granular. Connexival area about one-eighth as wide as abdominal disk above and beneath. Genital capsule transverse, strongly retracted in abdominal apex and completely covered from above by a projecting tergal plate.

Genotype: *Elasmocoris setigerus* Usinger, n. sp.

***Elasmocoris setigerus* Usinger, new species**

Figure 3

*Female*.—Head slightly broader across eyes than long, 23 : 20, the interocular space three times as wide as an eye; median process of head (tylus and juga) very short and broad, produced in front of eyes for slightly less than length of eyes, with a setigerous tubercle on either side in front of juga, separated from (and slightly narrower than) antenniferous tubercles by impressed grooves. Antenniferous tubercles each with a setigerous tubercle at outer angle. Head abruptly compressed laterally just behind eyes and then once more dilated and bearing setigerous tubercles; disk arcuately impressed between and behind eyes, the surface of anterior lobe finely punctate, that of posterior lobe finely transversely rugose. Rostrum short and stout, the first segment slightly broader than long, 17 : 15; with four setigerous tubercles at base above, second segment one-third longer than first, narrowed apically, third segment slightly shorter than first and one-third as wide, at base, as first segment. Under surface of head with a group of three prominent setigerous tubercles on either side between rostrum and eyes. Antennae a little longer than head, pronotum, and scutellum together, 75 : 67; proportion of segments one to four as 7 : 27 : 26 : 15; first and second segments with scattered setigerous tubercles or stout spines, last two segments very slender, bearing scattered erect bristles.

Pronotum half again as long as head, 40 : 27; not quite one-third broader across humeri than long on median line, 57 : 40; anterior lobe finely punctate, posterior lobe coarsely granular, lateral margins each with a row of setigerous tubercles at and behind middle; anterior acetabula prominent beyond antero-lateral margins, bearing two large and three small setigerous tubercles dorsally; posterior margin broadly sinuate above basal angles of scutellum and arcuate at middle. Scutellum nearly three times as broad as long, subrounded posteriorly, divided by posteriorly divergent longitudinal impressions into ill-defined lateral lobes and a median apical lobe, surface finely punctate and sparsely beset with erect bristles. Clavus and corium finely granular with short, backwardly directed bristles along lateral margins and with a long, pale bristle at middle of hind margin of sixth and seventh connexival segments.

Under surface strongly flattened. Pronotum three-fourths as broad between anterior coxae as long, slightly narrowed anteriorly with a postero-lateral arm extending on either side behind coxae and leaving a deep pit between base of arm and mesosternum; lateral margins, margins of stridulatory sulcus, and apex of postero-lateral arms with setigerous tubercles, the disk sparsely beset with erect bristles. Meso- and metasterna almost completely fused, with an

ill-defined oblique suture on either side extending from middle coxae toward anterior margin and with an elongate, pale, shallow depression extending posteriorly on either side from middle coxae sublaterally. Metasternum feebly depressed postero-laterally near hind coxae. Fused sternal area with a few setigerous tubercles along lateral margins and a few minute bristles on disk. Abdomen minutely punctate and very sparsely beset with small bristles; sutures indistinct except for deeply concave and medially sinuate hind margin of first segment. Stigmata concolorous, distinctly elevated, located sublaterally a little in front of middle of each segment. Connexivum ventrally much as on dorsal surface, finely punctured and with a latero-ventral series of short bristles along margins.

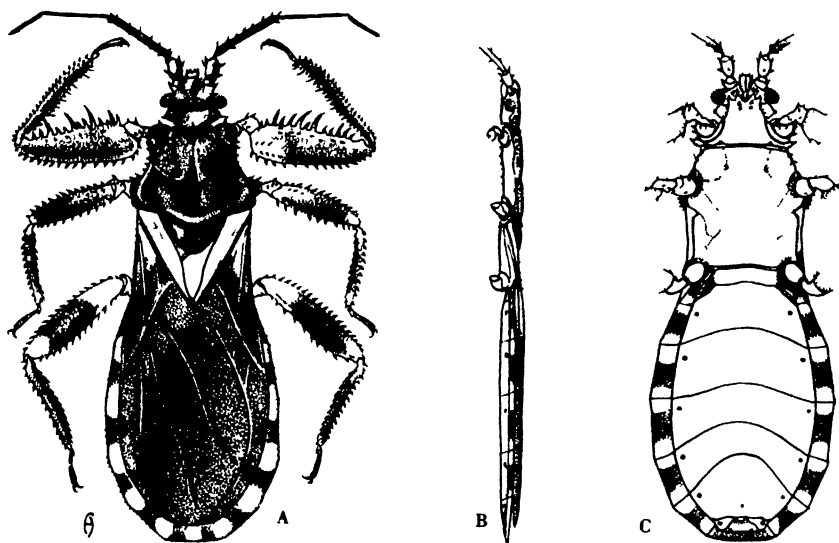


FIGURE 3. *Elasmocoris setigerus* Usinger, n. g. and n. sp.  
A, dorsal view; B, lateral; C, ventral.

Seventh ventral segment strongly sinuate anteriorly and nearly straight on its posterior margin. Genital segments concealed from above by a plate-like extension of eighth tergite which is nearly straight along its posterior margin. Ninth tergite vertical, broad and short with its disk depressed; situated well behind the apex of eighth tergite. Eighth ventrites restricted to either side of ninth tergite and bearing the spiracles of the eighth segment. There is a short, broad, posteriorly arcuate lobe at apex of ninth tergite which may be the tenth tergite. The valvifers and valvulae are all concealed.

Coxae short, suboval, the under surfaces subflattened, beset with scattered setigerous tubercles. Trochanters about as long as coxae, enlarged apically and beset with scattered setigerous tubercles. Femora with numerous setigerous tubercles arranged in longitudinal

rows, each femur with two prominent rows on inner face and two prominent rows on outer face. Most prominent row on inner dorsal face of front femora where the tubercles are half as long as thickness of femora. Femora beset with many small, scattered, setigerous tubercles and spines on upper and lower faces between longitudinal rows. Tibiae with three outer rows, two inner rows, and some intermediate rows of setigerous tubercles intermixed with long, stiff bristles. Tarsi with a few erect hairs.

Color dark brown to black and white, the head brown with black eyes, reddish ocelli, pale anterior process, white membranous apices of antennifous tubercles and base of rostrum, fulvous rostrum, brown basal two antennal segments and testaceous apical segments. Pronotum and scutellum brown. Hemelytra white on basal sixth; the remainder brown including the membrane with veins slightly darker. Connexivum above and beneath broadly white at transverse sutures between segments and dark brown to black at middle of segments. Thoracic sterna light brown; abdominal disk white. Legs fulvous to testaceous basally, darker beyond bases of femora except along inner faces. Tibiae dark brown and tarsi paler, the claws fulvous. Spines and bristles either alone or on tubercles, black.

*Male*.—Very similar to the female but with the connexival margins more broadly rounded laterally and rounding to a feeble, ill-defined emargination posteriorly. Eighth segment very large, plate-like, with an oval hole ventrally behind the broad connexival area through which the genital capsule protrudes. Genital capsule smooth, convex, two-thirds as broad as long, truncate at apex with a pair of rounded lobes projecting one-seventh of the total length of capsule beyond capsule.

*Size*.—Male, length 4 mm., width (connexivum)  $1\frac{1}{2}$  mm.; female, length  $4\frac{1}{4}$  to 5 mm., width (connexivum) 2 mm.

Holotype, female, No. 5272, Calif. Acad. Sci., Ent., Horqueta, Paraguay, October 18, 1933, Alberto Schultze, collector. Allotype, male, same locality as type but  $57^{\circ} 10' W.$ ,  $23^{\circ} 24' N.$ , 44 km. east of Paraguay River, April 26, 1933. Paratypes, two females, one with the same data as holotype and one the same as allotype. I am indebted to Mr. Frank Lutz of Philadelphia for the pair of specimens from east of the Paraguay River.

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A CLASSIFICATION OF LARVAE AND ADULTS OF THE GENUS *PHYLLOPHAGA* (COLEOPTERA: SCARABAEIDAE), by ADAM G. BÖVING. 1942. *Memoirs of the Entomological Society of Washington*, No. 2. Pages viii+95, 6 text figs., and 11 plates with 250 figs. 8 vo., cloth. Published by the ENTOMOLOGICAL SOCIETY; address, Bureau of Entomology and Plant Quarantine, Washington, D. C. Price, \$3.00.

The Entomological Society of Washington is to be envied for the material available for its *Memoirs*. With the greatest staff of experts in the world as the rank and file of its membership, and available to such the great resources of the national collections, its productions on taxonomic entomology rate as the very last word in authority. The research of no one in this group rates higher than that of Dr. Böving.

The present volume stands out in taxonomic literature because it not only describes, keys out and illustrates many species of *Phyllophaga* in both larval and adult stages, but is also a critical study of the evolutionary trends in the larvae as compared with the evolutionary trends in the adults. One study is based on larval characters and the other on the complex male genitalia. A third problem arises in the delineation of the genus on both larval and adult characters from the other genera of the scarabaeid Tribe Melolonthini. Early in the study the *Phyllophaga* of Cuba were separated from *Phyllophaga* and placed in two genera, *Cnemarachis* Saylor and *Clemora* Saylor (1942), (genitalic characters, Böving, 1942).

The present volume is one of the best studies to date of the problem of generic and subgeneric-group definitions on characters, larval and adult, in all of the orders with complete metamorphosis. It is the problem that haunts all taxonomists studying insects of the Holometabola: Revision after revision on adult characters has been made with the haunting dread that some iconoclast will study the larvae and proceed to rearrange treasured sequences of species. It is a ghost that has flitted in the low lighted background of taxonomy from its very beginning as a science, when John Ray reared hundreds of British Lepidoptera to better understand their classification (Ray, 1710, *Historia Insectorum*).

Twenty-one larval groups have been defined with a key to the known larvae of sixty species. The genitalia of the males of forty-two species are figured. The emphasis appears to be on larvae, the field in entomology to which the author has turned at every opportunity.

Dr. Böving is a person who has seldom travelled out of Washington but is one whom every taxonomist on the occasion of study in the national collections tries to meet, if for nothing else than the attempt to raise his own enthusiasm and to sharpen his own taxonomic efforts. Böving is an enthusiast in the best meaning of the term. Even better, he is able to impart enthusiasm. Doctor Böving was born and educated in Denmark and came to the United States in 1913, going immediately into the Bureau of Entomology, from which he retired in 1939. He has the high distinction of The Golden Cross of the Knights of Dannenbrog, from the Danish Government. His main interests have been in studies of the larvae of the Coleoptera.—C. H. K.

# GROSS ANATOMY OF THE LARVA OF THE WASP *POLISTES GALLICUS* (L.)

(Hymenoptera, Vespidae)

H. L. PARKER,

United States Department of Agriculture,  
Bureau of Entomology and Plant Quarantine

The larva of *Polistes gallicus* (L.) (fig. 1) is composed of the head, 3 thoracic segments, and 10 abdominal segments, although a protrusion below the anal opening gives the appearance of 11 abdominal segments. It is somewhat spindle-shaped, with the last 5 segments bent slightly dorsad. The body is whitish and the head brown. There are lateral lobes on abdominal segments 1 to 9, inclusive.

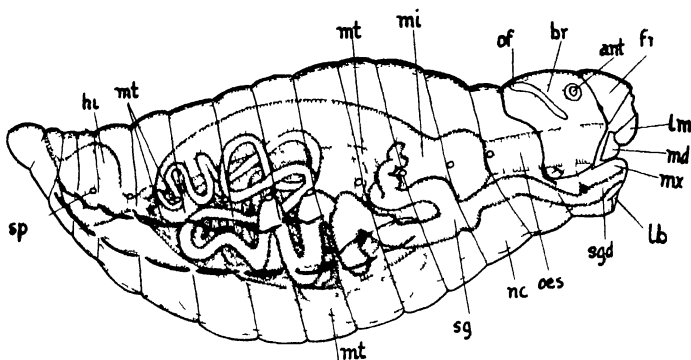
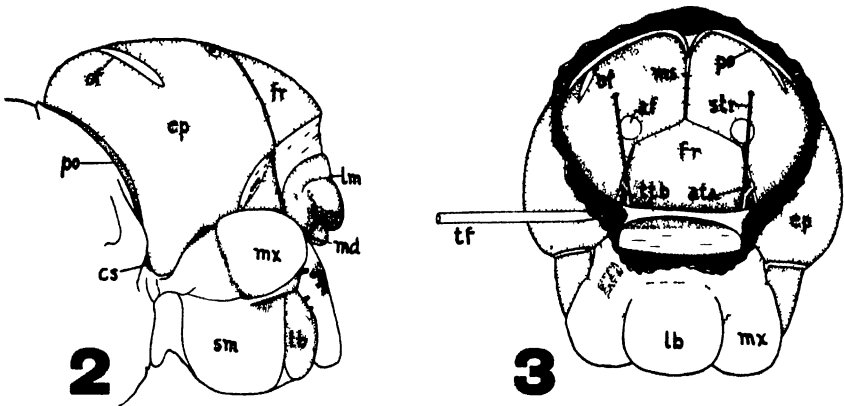


Figure 1. Larva of *Polistes gallicus*, drawn from right side, showing form and internal organs. *ant*, antenna; *br*, brain; *fr*, frons; *hi*, hind intestine; *lb*, labium; *lm*, labrum; *md*, mandible; *mi*, midintestine; *mt*, malpighian tubes; *mx*, maxilla; *nc*, nerve chain; *oes*, oesophagus; *of*, ocular fossa; *sg*, salivary gland; *sgd*, duct of salivary gland; *sp*, spiracle.

**The Head** (figs. 1-6).—The epicranium, mandibles, labium, and extremities of the labrum and maxillae are brown. The postoccipt (figs. 2, 3, *po*) is distinct but narrow; the cervical sclerome (fig. 2, *cs*) is small but distinct; the metopic suture (fig. 4, *ms*) is a distinct whitish line extending from the postoccipt to the apex of the frons; the frons (figs. 1, 2, 3, 4, 6, *fr*) is delineated dorsally by vague depressions slightly darker than the surrounding areas and is separated from the cranial halves by the parafrontal sutures (fig. 4, *pfs*), which extend to the anterior tentorial fossae; the clypeus (fig. 4, *cl*) is not differentiated except by an imaginary line drawn between the two anterior tentorial fossae (fig. 4, *atf*); below the clypeus is a white membranous area between it and the labrum (figs. 1, 2, 4, *lm*); the labrum is brownish at the edges, more or less unpigmented medially; and bears several dozen small, cir-



cular, sensory papillae (fig. 5, *lrs*) and sensoria; the ocular fossae (figs. 2, 3, 4, *of*) are long, white, anteriorly divergent depressions situated on the vertices of the cranial halves; the points of attachment of the superior tentorial rami (fig. 4, *saf*) are indicated by small depressions above the antennae; the antennal foramina (fig. 3, *af*) are two light spots situated near the dorso-lateral angle of the frons, these spots bearing the antennae (figs. 1, 4, 5, 9, *ant*). There are no condyles on the mandibles, their articulations being entirely membranous; their tips are darker than the basal portion and are bidentate (figs. 1, 2, 4, 6, *md*); the maxillae (*mx*) are fleshy lobes with a darker terminal portion except for the extreme distal part, which is whitish and bears two (each) palpus-like structures (fig. 2, 4, 6, *mx*; fig. 5, *mxp*), the inner or lacinial one



Figures 2 and 3. Head of larva of *Polistes gallicus*; 2, lateral view; 3, posterior view. *af*, antennal foramen; *ata*, anterior tentorial ramus; *cs*, cervical sclerite; *ep*, epicranium; *fr*, frons; *lb*, labium; *lm*, labrum; *md*, mandible; *ms*, metopic suture; *mx*, maxilla; *of*, ocular fossa; *po*, postocciput; *sm*, submentum; *str*, superior tentorial ramus; *tf*, tentorial fossa; *tib*, transverse tentorial bridge.

being three-branched, although the branches are short, and the outer one conical-truncate; the unpigmented surface of the maxillae is covered with minute spines directed inwardly; the labium (figs. 1, 2, 3, 4, 5, 6, *lb*) is oval, slightly wider above, brown except the area around the palpi, which is white; the palpi (fig. 5, *lp*) are dark brown, conical, truncate; immediately dorsad of each palpus are 9 coarse setae, and below are several circular papillae; the salivary gland opening (figs. 4, 5, *sdm*) is simple, transverse, and oval; it has no particular spinning device; the area generally known as the hypostomal region is not differentiated; the tentorial fossae (fig. 3, *tf*) are indicated by the point of the needle placed therein; the tentorium consists of the transverse tentorial bridge (fig. 3, *tib*), the anterior tentorial rami or arms (figs. 3, 7, 9, *ata*), and the superior rami (figs. 3, 7, 9, *str*); the arms are attached to the head skeleton at the anterior fossae (fig. 4, *af*). The epicranium and frons are sparsely covered with minute setae.

**The Muscles of the Head** (figs. 7, 8, 9).—The labium has two sets of muscles extending from its borders to the vicinity of the salivary gland

opening, one set above (14) and one below (17); it has in addition another set (11) extending from the lateral posterior margin of the throat region to the dorso-lateral edges of the labium; a part of this

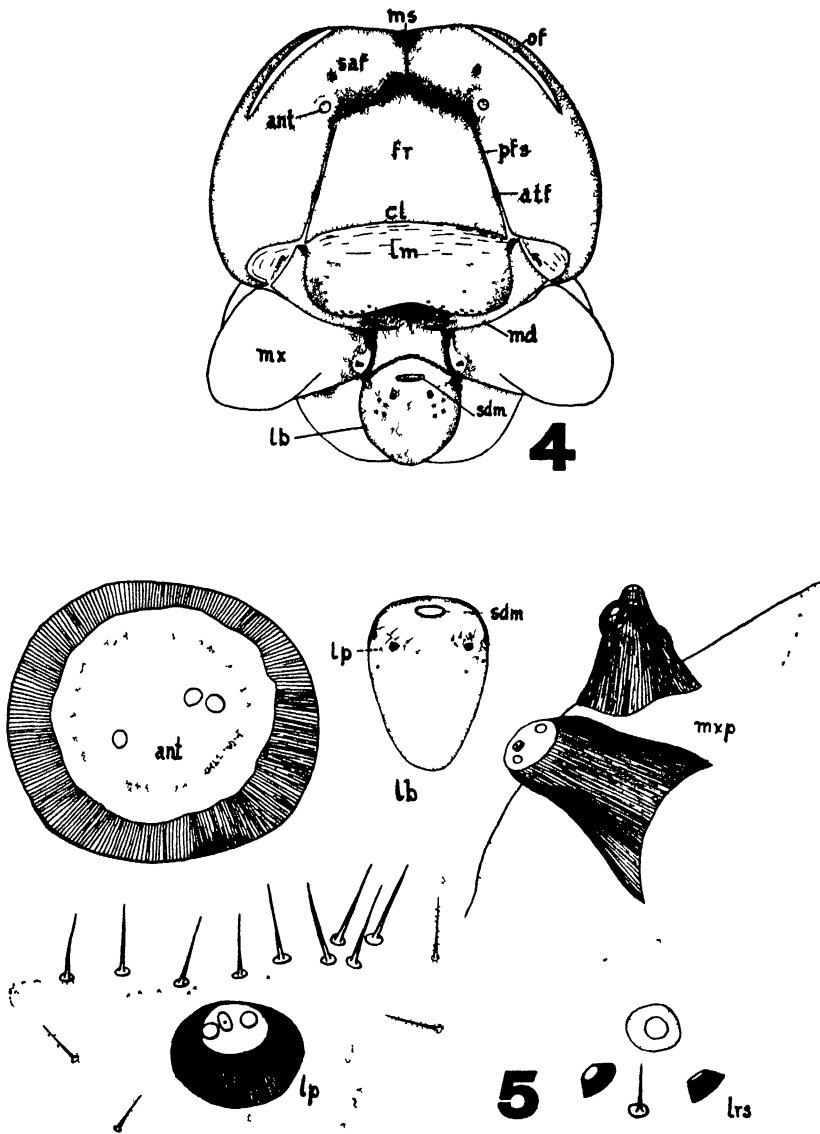
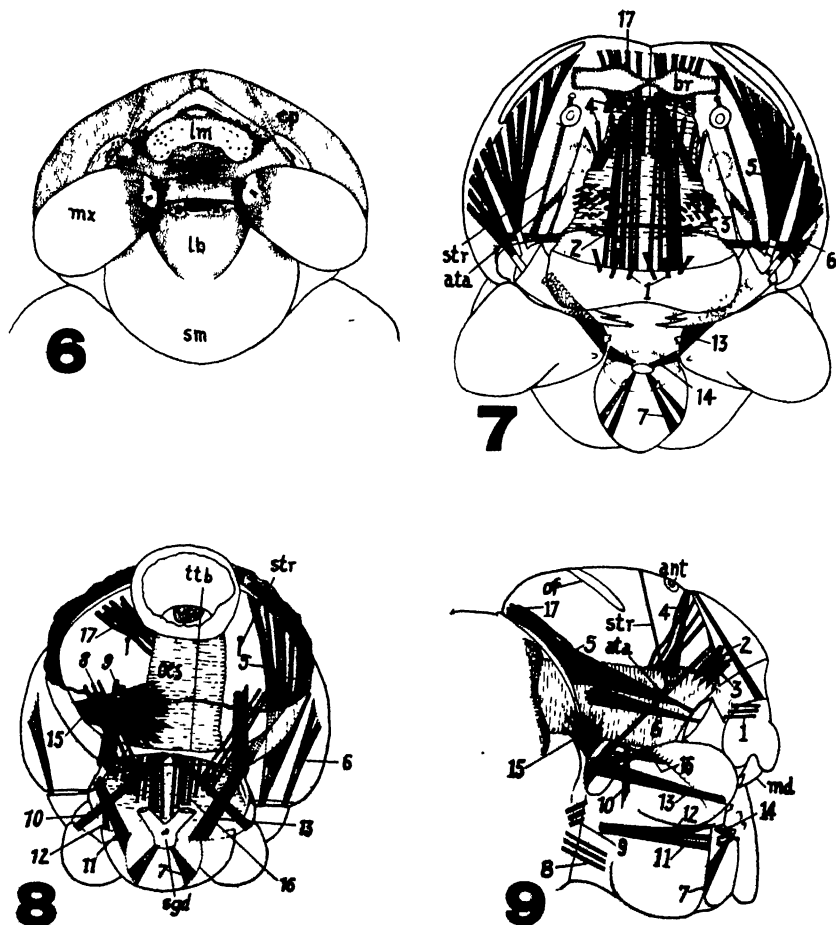


Figure 4. Head of larva of *Polistes gallicus*, anterior view. 5. Detailed structure of various sensory organs of larva of *Polistes gallicus*. *ant*, antenna; *atf*, anterior tentorial fossa; *cl*, clypeus; *fr*, frons; *lb*, labium; *lm*, labrum; *lp*, labial palpus; *lrs*, sensory papilla of labrum; *md*, mandible; *ms*, metopic suture; *mx*, maxilla; *mxp*, maxillary palpus; *of*, ocular fossa; *pfs*, parafrontal suture; *saf*, superior tentorial fossa; *sdm*, salivary gland opening.

group (12) branches off and attaches to the inferior border of the maxilla; the maxilla has in addition to these muscles (12), a pair (13) extending from the superior edge of the lateral part of the tentorial bridge to the interior apex of the maxilla near the palpus, and another (10) extending from the inferior median portion of the tentorial bridge to the external posterior margin of the maxillary lobe; the throat region has a group of muscles (8) extending from the anterior lateral margin of the first thoracic segment to a point on the floor of the throat near the median line just posterior to a lobe which appears to be the submentum; the



Head of larva of *Polistes gallicus*; 6, ventral view; 7, anterior view, showing internal structures; 8, posterior view, showing internal structures; 9, lateral view, showing internal structures. *ant*, antenna; *ata*, anterior tentorial ramus; *br*, brain; *ep*, epicranium; *fr*, frons; *lb*, labium; *lm*, labrum; *md*, mandible; *mx*, maxilla; *oes*, oesophagus; *of*, ocular fossa; *sgd*, duct of salivary gland; *sm*, submentum; *str*, superior tentorial ramus; *ttb*, transverse tentorial bridge. The numbered structures are muscle groups, discussed in the text.

mandible has two sets of strong muscles, one (6) to open it and one (5) to close it; the former attach to the epicranium laterally, and the latter to the posterior border; the labrum has a group of short muscles (1) to close it, and another group (2) from its upper border extending to the superior margin of the frons to raise it; the oesophageal muscles are numerous; a group of short muscles (3) extend from the superior surface of this organ to the clypeus, and another group (4), likewise situated but farther posteriorly, extends up to the cranium just above the frons; a similar group posterior to the brain (17) extends from the oesophagus to the posterior margin of the head capsule on each side of the median point; ventrally the oesophagus has a group (16) composed of many elements extending from the lower wall of this organ to the inferior border of the tentorial bridge, and another strong group (15) on each side extending to the lateral posterior margin of the head capsule slightly below the lateral line.

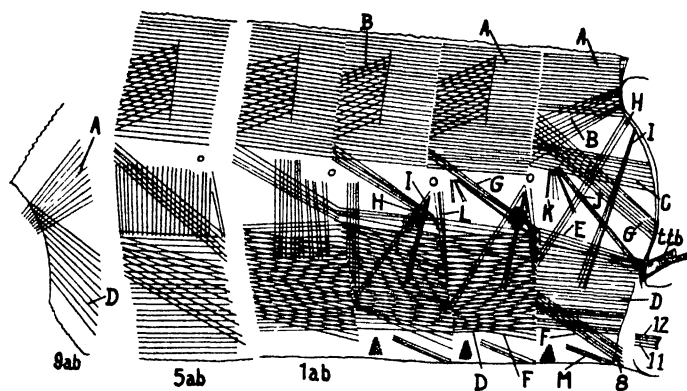


Figure 10. Diagram of body muscles of larva of *Polistes gallicus*. *ab*, abdominal segment; *ttb*, transverse tentorial bridge. Numbers and letters designate muscle groups, discussed in the text.

*The Integumentary Muscles of the Body* (fig. 10.)—These muscles are abundant and complicated. It is not necessary to describe them in detail here, but their arrangement can be observed in the diagram, where each black line represents a muscle strand. The general pattern is best seen in the fifth abdominal segment, where dorsally there is a straight longitudinal group (A) extending the entire length of the segment, and an oblique group (B) extending half the length of the segment; ventrally these groups have their homologues (D and F); in the lateral region of the segment there is a transverse group extending from below the spiracular line downward to the first elements of the longitudinal group D, and there is an oblique set extending from the posterior margin of the segment at the spiracular level downward across the segment to near the point of attachment of the first elements of the group D. This pattern is consistent throughout the other abdominal segments except that in the last segment there are only two groups and these are longitudinal, the dorsal groups extending from the tegument to the posterior

end of the hind intestine. In the thorax the pattern is essentially the same; the elements of group F are more abundant, and in addition there are several oblique elements not seen in the abdomen, principally two sets (H and I) extending from under the spiracle obliquely downward and posteriorly, H to the posterior margin of the segment, and I to the middle of the same; in the first thoracic segment these two groups have their upper articulations on the postocciput; there are short, oblique groups on the ventral floor of the thoracic segments as well (M).

*Internal Organs* (fig. 1).—The respiratory system consists of 10 spiracles and a tracheal system. The first and second spiracles are situated on the posterior margin of the first two thoracic segments, the third on the intersegmental line, and the fourth to tenth on the anterior margins of abdominal segments 2 to 8; the tracheae are of the usual type, with lateral trunks, spiracular branches, anterior and posterior commissures, and ramifying branches. In addition there are ventral connecting commissures in the last two thoracic and first seven abdominal segments.

The alimentary tract consists of a straight muscular oesophagus (*oes*) extending to the second thoracic segment, a somewhat bulbous mid-intestine (*mi*) extending to the sixth abdominal segment, and an almost spherical hind intestine (*hi*) terminating with a thin, tubelike rectum at the dorsal anus posteriorly on the tenth abdominal segment; the salivary glands (*sg*) are long, twisted tubes slightly ramified and drawing out to a finer tube at the end, which is in the sixth abdominal segment; the malpighian tubes (*mt*), two on each side, are rather long, simple tubes, curved and twisted, lying mostly in the first six abdominal segments, and emptying as usual in the anterior portion of the hind intestine, which is distinct from the posterior portion.

The nervous system is of the usual type, the brain being composed of two transverse quasicylindrical lobes.

*Source of Material*.—The specimens studied were obtained in the Mediterranean region of France.

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#### INVESTIGATIONS OF INDIANA LAKES AND STREAMS, Vol. II.

Articles 1-14, 296 pages, 1942. Many tables and figures. Published by Indiana Department of Conservation and the Department of Zoology, Indiana University. Price 75 cents from Department of Conservation, Division of Fish and Game, Indianapolis, Indiana.

We wish to call to the attention of those entomologists interested in insects as food of fishes the work being done under Prof. W. E. Ricker, Limnologist of Indiana University, Department of Zoology, on the life in the streams and ponds in that state. (Entomologists know Ricker as an authority on stone flies.) This work was started under Prof. Will Scott of that Department in 1922. It has been continued and has been speeded up under Prof. William E. Ricker, who was trained in Toronto and had previously worked with Canadian Fisheries authorities in British Columbia. A solid heavy program is now under way in Indiana to develop fishing for sportsmen in its many streams and numerous glacial lakes.

The present volume contains no data on insects but its various articles cover investigations on the fish life in as many ponds and streams. Ricker's own contributions of about 200 pages (author and co-author) are concerned with populations and age groups. The use of fish scales as indicators of age is highly developed in the work and would be of interest to students of fish food who should know the ages of fish studied.—C. H. K.

**THE BIOLOGY OF HADRONOTUS AJAX GIRAULT  
(HYMENOPTERA - SCELIONIDAE), A PARASITE IN  
THE EGGS OF SQUASH-BUG (ANASA  
TRISTIS DeGEER)<sup>1</sup>**

STEWART C. SCHELL,  
North Carolina State College,  
Raleigh, North Carolina

**INTRODUCTION**

*Anasa tristis* DeGeer is a common pest on squash vines in North Carolina, as well as in many other parts of the United States. *Hadronotus ajax* Girault is one of the more important parasites attacking the eggs of the squash-bug at Raleigh, North Carolina. The squash-bug is difficult to control by chemical means, so even a partial natural control by parasites is of considerable value. An attempt has, therefore, been made to learn something of the biology of this parasite. The work was done during the summers of 1940 and 1941, in the department of Zoology and Entomology of the North Carolina State College at Raleigh, North Carolina.

*Hadronotus ajax* Girault was described by Girault in 1920 from a series of specimens reared at Baton Rouge, Louisiana, from eggs of *Anasa tristis* DeGeer. The species is undisputed, there being no recognized synonyms, and it has never been reared from any host other than the squash-bug. The species has been found in Alabama, Arizona, Illinois, Louisiana, Missouri, North Carolina, Ohio, Tennessee, and Texas.

Since *Hadronotus ajax* was described nothing has been published concerning the species, and work done on other species in the genus is somewhat fragmentary.

Girault (1913) observed the oviposition of *H. carinatifrons* Ashmead in the eggs of the squash-bug at Paris, Texas. Dry (1924) obtained sex ratio data for *H. antestiae* Dodd, a parasite in the eggs of the coffee-bug (*Antestia lineaticollis* Stål). The sex ratio was approximately four females to one male. Parthenogenesis, occurring rarely, produced only males. Whitfield (1932) found 70 per cent of the eggs of *Agonoscelis versicolor* F. parasitized by *H. antestiae* Dodd in the Sudan. Development required eight to ten days. Van Der Vecht (1933) bred *Hadronotus* sp. from eggs of *Dasynus piperis* China in the Netherland Indies. The parasite developed in fourteen to seventeen days; 22 per cent were males; adults lived an average of twenty-six days and a maximum of fifty-four days.

<sup>1</sup>The writer expresses appreciation for the helpful criticism and suggestions given by Dr. Z. P. Metcalf and Dr. B. B. Fulton, and especially to the latter for aid with illustrations. I am also grateful for the assistance given by Dr. R. Harkema. Acknowledgment is made to Mrs. Schell for typing the manuscript. Thanks are extended to Messrs. C. F. W. Muesebeck, A. B. Gahan, and D. G. Hall, of the United States National Museum, for determination of parasite species.

## MATERIAL AND TECHNIQUE

The squash-bugs and parasites were found in a squash field one-fourth mile from the laboratory at Raleigh, North Carolina. Adult male and female squash-bugs were collected and placed in quart Mason jars with fresh squash leaves. Unparasitized eggs were thus obtained; they were removed from the jars each morning, placed in tightly stoppered glass vials and refrigerated at 45° F. until needed.

Parasitized clusters of squash-bug eggs were collected in the field, placed in cotton plugged glass vials, and brought into the laboratory. As the parasites emerged they were transferred to other vials and fed dilute honey for two to three days in order to allow time for mating and development of eggs. At the end of this time three or four females were placed in vials containing one or more clusters of unparasitized host eggs. Two hours time was allowed for oviposition, and then the parasites were removed. The date and time of oviposition were recorded on each vial.

At chosen intervals host eggs were removed and opened, and the stages of the parasite studied. Dissections were made in a modified Ringer's physiological saline. Levy's 1/11 stock saline for insects was also used in some of the dissections. Specimens would remain alive and apparently normal for two to three hours in either of these solutions.

The host egg was placed on a clean glass slide with a few drops of the saline solution and dissected under a binocular dissecting microscope ( $\times 40$ ). Dissecting needles were made by mounting minuten nadeln in match sticks. Subsequent examinations were made with the compound microscope after a cover glass was applied. All observations were made from living material.

## MATING AND OVIPOSITION

Mating occurs shortly after emergence. Male and female parasites kept in vials never showed a readiness for mating except when placed under a bright light or in sunlight. This factor in the environment apparently serves as a stimulus for mating.

Previous to copulation the male mounts the female and rapidly vibrates his antennae against those of the female. This may continue with brief intermissions for a period of ten to twenty minutes. Meanwhile the female moves about carrying the male with her. Finally, the male parasite moves toward the posterior end of the female, flexes his abdomen slightly, extends the aedeagus, which curves ventrally, and inserts it into the genital opening of the female for a period of five to ten seconds, during which time both the male and female remain motionless except for a slight pulsating movement of the male abdomen. Immediately after copulation the male dismounts, and after a brief pause repeats the process with another female parasite. Occasionally two males will simultaneously attempt to mate with a single female.

The female parasite is not ready to release eggs for a period of approximately forty-eight hours after emergence. Dissection revealed that this time is required for the development of eggs in the ovarioles. Fully developed eggs in the ovarioles are not as plump as they are immediately after oviposition. It is possible that they absorb fluid after entering the host egg.

The female parasite carefully examines each host egg by repeatedly tapping the surface of the egg with her antennae. When a suitable host egg has been found, the female will back up to the egg until the tip of the abdomen touches the surface; the ovipositor is extended so that just the tip is exposed and the chorion of the host egg is punctured. The ovipositor of *H. ajax* is not extensible to the degree that it is in those species of Scelionidae which parasitize the eggs of Orthoptera. During oviposition the female braces herself against adjacent host eggs and maintains contact with the one in which she is ovipositing by pulling backward with her hind legs which are extended posteriorly around the egg. The antennae remain flexed and lie against the frons during oviposition. The entire process may require from five to twenty minutes. Normally only one egg is deposited in each host egg; however, when the number of host eggs is limited, the same or a different female parasite may deposit additional eggs, only one of which ever develops beyond a first-instar larva.

#### DEVELOPMENT

*The Egg and Its Development* (figs. 1-6).—The egg of *H. ajax* (fig. 1) is stalked, and the chorion is a thin pellicle. The average size before oviposition is 0.18 mm. long by 0.09 mm. in diameter; after oviposition it is 0.21 mm. long and 0.118 mm. in diameter; the stalk is 0.121 mm. long and 0.012 mm. in diameter.

The eggs are plump with a glossy surface and float freely in the fluid medium of the host egg. The contents are a rather uniform mass of oily droplets, probably yolk material, which after several hours separate into two unequal portions, the smaller mass occupying the distal or polar region of the egg, while the larger mass fills the remainder of the egg. This larger mass appears to undergo rapid division and within three to five hours after oviposition a blastosphere is formed (fig. 2).

Meanwhile the polar mass, which probably constitutes the polar bodies, is utilized in part for the formation of cellular embryonic membrane which gradually extends around the blastosphere until the latter is completely enveloped. The cells of this membrane are not contiguous, but are separated by areas of cuticular substance. The nuclei are quite prominent in some of the cells. Similar membranes have been found in both polyembryonic and monembryonic species. They are believed to function in the absorption and transfer of food material from the host tissue to the embryo; they are commonly found in those eggs in which the chorion is shed at an early stage. Two to three hours are required for the formation of the cellular membrane, and about the time it is completed, the blastosphere becomes slightly elongate. At one end two rounded enlargements appear. This is the definitive anterior end of the embryo, and a mandible ultimately arises from each enlarged area.

Meanwhile the embryo becomes flexed; the cells in the concave portion become thickened, and a germ band develops. About the same time that flexure occurs, the egg chorion is lost; figures 3 and 4 show successive steps in this process. The chorion ruptures, and the embryo enveloped by the cellular membrane passes out through the opening,



leaving the chorion behind as a crumpled pellicle. The embryo is now about ten hours old, and is plainly visible through the membrane (fig. 5).

Shortly after the chorion is lost, the embryo develops a caudal horn, labial projection, and mandibles. At this time a very thin membrane, resembling a mere cuticle, appears between the embryo and the cellular membrane. It is a simple sac-shaped pellicle without extensions over the appendages. The origin of this inner membrane was not determined. The writer believes it to be analogous to the "hatching membrane" referred to by Snodgrass (1935). This type of membrane has been observed in other holometabolous insects.

When the embryo is fifteen to seventeen hours old, the cellular membrane ruptures, and the embryo, still flexed and invested by the hatching membrane, escapes (fig. 6). The loss of the cellular membrane may be caused by enzymatic action, but certainly not by any mechanical action.

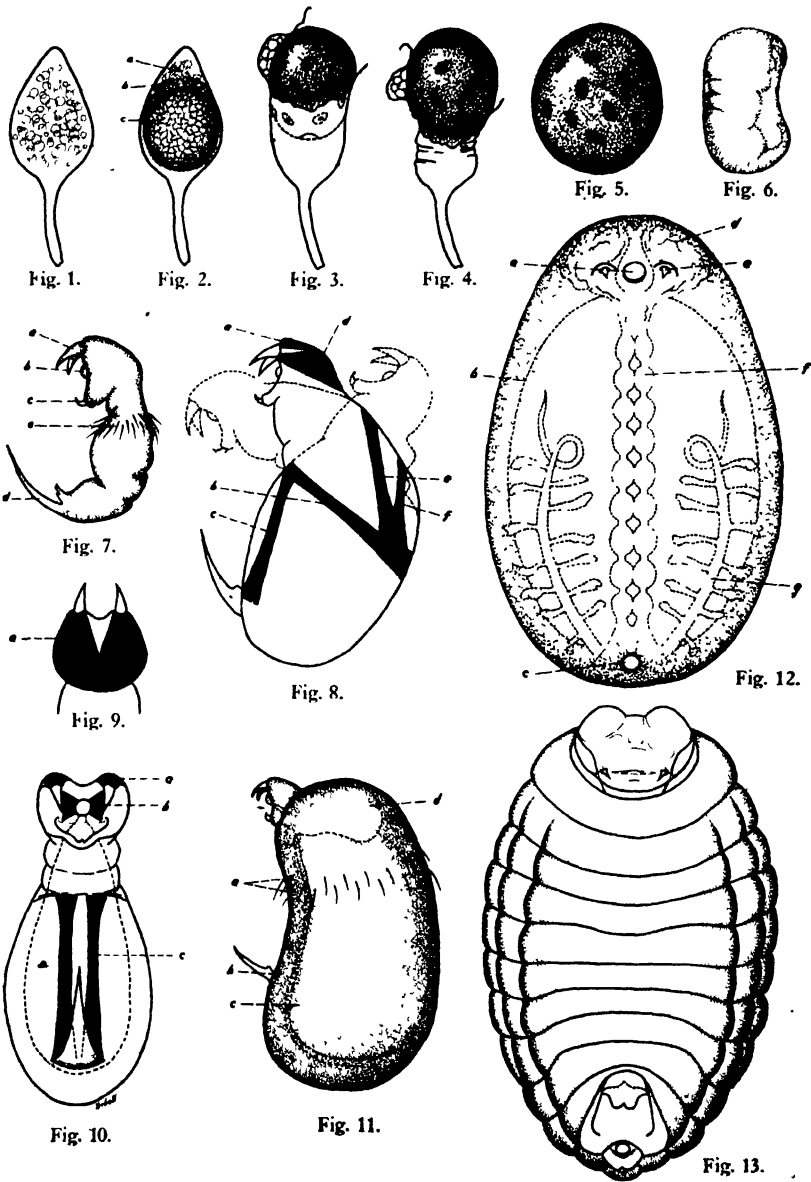
Hatching is completed in about eighteen to twenty hours with the loss of the hatching membrane. The first movement of the mandibles along with a sudden straightening of the embryo causes the membrane to rupture, and it is soon left behind by the active first-instar larva. The loss of the hatching membrane might be regarded as an embryonic molt.

*First-Instar Larva* (figs. 7-11).—The first-instar larva (fig. 7) is of the teleaform type as designated by Clausen (1940), "body segmentation not visible but the cephalothorax and abdomen separated by a constriction; the mandibles very large, usually fleshy and directed ventrad; the abdomen almost spherical with one or more rings of long delicate spines, and a long, heavily sclerotized blade-like process [caudal horn] directed ventrad, upon the last segment." Imms (1924) classes this type of larva under primary larva, and suggests that it develops from an egg containing little or no yolk and is compelled to emerge while still in an early embryonic phase. It hatches in a condition which, in other groups of insects, is passed in the egg. Packard (1898) supposes that the embryos undergo a premature development due to their rich and abundant supply of food and the high temperature of the egg, and are therefore hurried into a vermian existence on a plane scarcely higher than that of an active ciliated gastrula.

The larva just after hatching is 0.266 mm. long and 0.083 mm. wide.

#### EXPLANATION OF PLATE I

FIGURE 1. Parasite egg just after oviposition. 2. Parasite egg four hours after oviposition; *a*, polar mass; *b*, formation of cellular membrane; *c*, blastosphere. 3 and 4. Stages in loss of chorion. 5. Embryo enveloped by cellular membrane. 6. Embryo enveloped by hatching membrane. 7. First-instar larva just after hatching; *a*, mandibles; *b*, oral bulb; *c*, labial projection; *d*, caudal horn; *e*, girdle of spines. 8. First-instar larva (36-40 hours), lateral view showing muscle fibers; *a*, dorsal mandibular fibers; *b*, lateral fibers; *c*, ventral fibers; *d*, ventral mandibular fibers; *e*, latero-dorsal fibers; *f*, dorsal fibers. 9. Dorsal view of head of first-instar larva; *a*, dorsal mandibular fibers. 10. First-instar larva (36-40 hours), ventral view; *a*, dorsal mandibular fibers; *b*, oral fibers; *c*, ventral fibers. 11. First-instar larva (60 hours); *a*, girdle of spines; *b*, nerve cord; *c*, enteron; *d*, brain. 12. Second-instar larva; *a*, oral bulb; *b*, enteron; *c*, anus; *d*, brain lobes; *e*, mandible; *f*, nerve cord; *g*, tracheae. 13. Third-instar larva, ventral view.



and the caudal horn (fig. 7, *d*) is 0.127 mm. long. The larva is extremely active, continually moving the head and caudal horn up and down by alternate contractions of ventral and dorsal muscles (fig. 8). This type of movement serves to shred any host tissue that may have formed by this time and also serves to aid the larva in moving around in the host egg. The mandibles move up and down freely in alternate succession; and in addition to directing food material toward the oral opening, they also enable the larva to hold on to large pieces of host tissue while the caudal horn reduces it to pieces of acceptable size. The labial projection serves as a stationary trough for food material as it is taken into the oral opening.

The larva becomes less active as it increases in size; and as the host tissue is consumed, the enteron becomes greatly distended (fig. 11, *c*). By the time the larva is half grown, a pronounced peristalsis is evident. The peristaltic waves may arise at either end and travel the full length of the gut, or they may start in the middle and travel toward either or both ends.

The first-instar larva is ready to molt forty-five to fifty hours after hatching. By this time it has made approximately a four-fold increase in size, having a body length of 0.96 mm. and a diameter at the widest part of 0.59 mm.; however, during the entire first instar the mandibles, labial projection, caudal horn, and cephalothorax have remained constant in size. All of the increase in size takes place in the abdominal region.

The old cuticle gradually becomes loosened; the larva repeatedly contracts the posterior part of the body; soon the cuticle splits on the anterior dorsal region and is slowly worked down over the head and backward over the body, and, finally, slips off at the posterior end. The mandibles, caudal horn, labial projection, and girdle of spines are cast off with the molted cuticle.

*Musculature of the First-Instar Larva* (figs. 8-10).—There are seven pairs of muscle fibers responsible for the active movements of the first-instar larva; figures 8, 9 and 10 show the arrangement of these fibers. They appear as thin elastic bands attached at both ends to the inner surface of the integument. Appropriate terms are applied according to their position or connection with certain structures.

A contraction of the ventral fibers (fig. 8, *c*) causes the caudal horn to be drawn toward the cephalothorax. When the lateral fibers (fig. 8, *b*) contract, the cephalothorax is drawn toward the caudal horn. These two movements occur simultaneously. Contractions of the latero-dorsal (fig. 8, *e*) and the dorsal fibers (fig. 8, *f*) pull the anterior part of the body in a dorsad direction. The lateral and latero-dorsal fibers also function in turning the anterior region of the body away from the median line. Such a movement can be induced by lightly touching the lateral region of the larva with the point of a dissecting needle.

The mandibles are moved by the ventral and dorsal mandibular fibers (fig. 8, *a*, *d*). Usually they are moved up and down alternately. A set of oral fibers (fig. 10, *b*) move the oral bulb in and out. This movement seems to create a suction and draws the food material into the short esophagus, which opens into the large sac-shaped enteron. The labial projection is immobile.

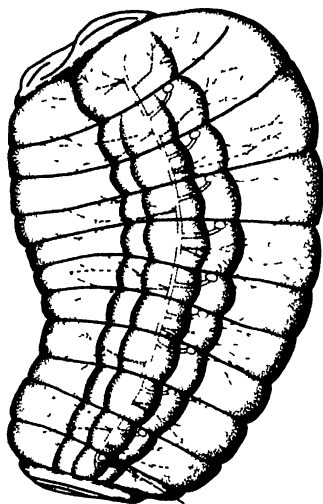


Fig. 14.

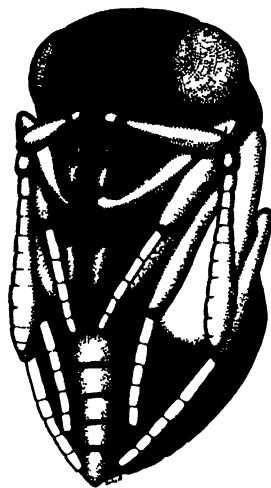


Fig. 15.

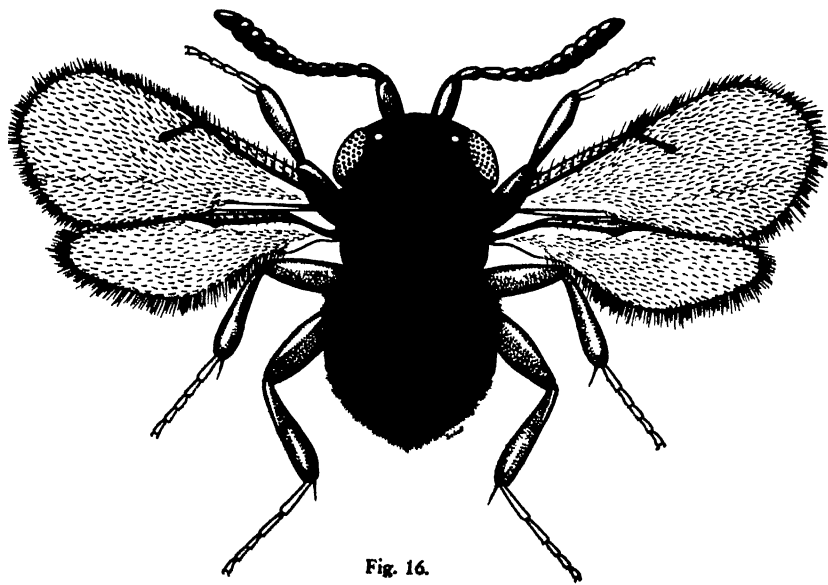


Fig. 16.

#### EXPLANATION OF PLATE II

FIGURE 14. Third-instar larva, lateral view; *s*, functional spiracle. 15. Pupa.  
16. Adult female.

*Second-Instar Larva* (fig. 12).—The second-instar larva is sacciform with "the body bag-like and flattened, without segmentation, and lacking a tracheal system," according to Clausen (1940). In this instar the enteron is still a simple sac filled with food material from the host egg, and occupying fully three-fourths of the haemocoel. The oral opening and oral bulb are similar to those in the first-instar larva. The anal opening is faintly outlined but the proctodaeum has not yet joined the enteron. In specimens fixed in Bouin's fixative the paired ventral ganglia, longitudinal commissures, lobes of the brain, and the beginnings of a tracheal system can be seen as opaque masses.

During the early part of the second instar, there is still some food material available in the host egg. The parasite ultimately consumes all of this. Peristalsis of the gut wall is very pronounced throughout this instar. The duration of the instar is twenty to twenty-four hours. As the time for molting approaches, many of the features of the third-instar larva are visible through the old cuticle. Preliminary to ecdysis, the old cuticle becomes loosened, giving the larva a very flaccid appearance. The larva rapidly and repeatedly flexes the body ventrally, and at the same time, by contraction of the posterior region, causes the anterior part of the body to increase in size. The old cuticle splits along the ecdysial line and gradually peels down over the head and toward the posterior part of the body from which it is finally cast. The cast cuticle is extremely thin and transparent, and unless molting is actually observed and the cuticle examined as soon as it is cast, the observer would undoubtedly miss it entirely.

*Third Instar Larva* (figs. 13 and 14).—The third-instar larva is hymenopteriform which, as characterized by Clausen (1940), has the "body spherical to spindle shaped, usually twelve to thirteen visible segments, integument bare or with sensory setae and cuticular spines." The molt to this stage occurs at sixty-four to sixty-six hours after hatching. Following the molt the average length is 1.76 mm. and width 1.12 mm.

A functional tracheal system first appears with this instar (fig. 14, *a*). The larva is metapneustic, the only functional spiracles being the posterior pair. These spiracles open into a funnel-shaped enlarged end of the spiracular tracheae. Throughout the first and second larval instars, the host egg contains fluid food material; no tracheal system is present in the parasite larva; and respiration is probably cutaneous. By the time the third larval instar is reached, all of the host tissue has been consumed, and respiration can then be carried on through the tracheal system.

During the latter part of the second instar, the larva becomes oriented with the head toward the opercular end of the host egg. This position is maintained, the third instar larva being very inactive. Toward the end of the instar, a thin brown parchment-like cocoon is produced by the larva. The writer was not able to determine just how the cocoon was formed. It is closely applied to the inner surface of the host egg chorion, but is not attached to it.

The formation of the cocoon marks the beginning of the prepupal stage. Shortly after the appearance of the cocoon, the larva discharges the meconium, consisting of fifteen to twenty disc-shaped fecal pellets

embedded in a semitransparent gelatinous mass, which invariably rests on the mid-ventral surface of the prepupa. The prepupa lies with the dorsum toward the basal surface of the host egg. The duration of the prepupal life is ten to twelve hours, at the end of which time the third molt occurs, the process being similar to that in previous molts. The awl-shaped mandibles could be seen in exuviae cleared in beechwood creosote. They are 0.049 mm. in length and amber-colored. The duration of the entire third instar is approximately forty-eight hours. The entire larval life requires five to six days.

*Pupa* (fig. 15).—The average size of the pupa is 1.5 mm. in length and 0.8 mm. in width; approximately a 20 per cent reduction in size is evident as compared to the third-instar larva. The newly formed pupa is entirely white. After the first twenty-four hours the entire head, dorsum and venter of the abdomen, the mesosternum, and the scape of the antennae become black; the compound eyes are red. At the end of forty-eight hours, the remainder of the body is black with the exception of the pleural membranes, which are quite prominent and remain white during fully half of the pupal life.

The pupa stage is brought to a close with the pupal molt which consists of the loss of a thin cuticle which completely ensheaths the pupa with extensions over the appendages. The ecdysial line is plainly visible, extending along the median dorsal region of the thorax and abdomen. When the split occurs the cuticle passes down over the thorax, head, and abdomen; and finally the legs, wings, and antennae are withdrawn from their sheaths.

The duration of the pupal stage is nine to ten days, or approximately two-thirds of the entire life cycle.

*Adult* (fig. 16).—The adult gnaws an exit in the chorion of the host egg with its mandibles. During emergence the head appears first; then the prothoracic legs are extended over the edge of the opening to aid the parasite to draw the rest of the body through. Post-emergence remnants in the host egg are the meconium, the cocoon, and the exuviae of the third-instar larva and of the pupa.

Adults kept in cotton-plugged vials in the laboratory and fed daily with diluted honey, lived as long as twelve days at a temperature of 75°–85° F. Specimens kept in tightly stoppered vials in the refrigerator at 45° F. remained alive for periods of five to six weeks without receiving food or water. The average body length of the adult is 1.4 mm.

## BIOLOGICAL CHARACTERISTICS OF HADRONOTUS AJAX

*Parthenogenesis*.—Tests for parthenogenesis were made by placing parasitized host eggs individually in small gelatin capsules. As the parasites emerged in this isolated condition, individual unmated females were released into small glass vials, each of which contained a cluster of unparasitized squash-bug eggs, and were allowed to oviposit.

A total of 154 parasites was produced parthenogenetically in this manner; all of them were males (arrhenotokous). Although parthenogenetic reproduction is possible, it is undoubtedly of rare occurrence under natural conditions. Of numerous parasitized egg clusters

collected in the field, and from which emergence records were taken, only four clusters ever produced an entirely male progeny, indicating a possible natural case of parthenogenesis.

**Percentage of Parasitism.**—The percentage of host eggs found parasitized in large collections made in the field during the month of August, 1940 and 1941, were: August, 1940, 23.0 percent parasitism; August, 1941, 42.0 percent parasitism. Most of the adult parasites and squash-bug nymphs obtained from these collections were released in the field as soon as they emerged.

**Number of Generations.**—The parasites appear in the field about the time that the first squash-bug eggs are deposited. The earliest parasite emergence, from host eggs collected in the field, occurred on July 24, 1941. The final emergence occurred September 19, 1941. The normal life cycle requires 15–16 days. There is then sufficient time for approximately four complete generations of the parasite. This time limit for effective parasitism is imposed by the squash-bugs, which cease egg-laying by late August in this locality.

**Fecundity.**—The average number of eggs produced is 16 per female. Data concerning the number of eggs the female parasites were capable of producing was obtained from two sources, (1) dissection of gravid females, and (2) dissection of host eggs after oviposition by a single female parasite; fresh, unparasitized host eggs had been supplied daily until the parasite died. Dilute honey was fed.

**Sex Ratio.**—Records were kept of the sex of parasites emerging from numerous clusters of host eggs collected in the field. The ratio of males to females was 1 : 5. Graham (1939) expresses the sex ratio as the ratio of females to the total population, and refers to this as the sex factor. The sex factor for *Hadronotus ajax* is 0.83.

**Biotic Potential.**—The biotic potential of an insect species, according to Graham (1939), is "its ability to multiply in a given time when relieved of all environmental resistance."

$$\begin{aligned} B. P. &= p(zy)^n \\ &= 1(13.3 \times 1)^4 \\ &= 31,290 \end{aligned}$$

$$\begin{aligned} p &= \text{original population (1)} \\ z &= \text{product of the number of eggs per} \\ &\quad \text{female and the sex factor } (16 \times 0.83 = \\ &\quad 13.3) \\ n &= \text{number of generations (4)} \\ y &= \text{number of progeny from a single} \\ &\quad \text{egg (1)} \end{aligned}$$

**Superparasitism.**—Rarely was more than one parasite egg, or first-instar larva ever found in any individual host egg under normal conditions. However, when host eggs were scarce and female parasites numerous (in vials) as many as five parasite eggs were found in a single host egg. Not more than one larva per egg ever developed beyond the first instar, making attempts at superparasitism definitely unsuccessful.

**Other Species of Parasites Bred.**—In addition to *Hadronotus ajax* Girault, the following parasites were bred: *Ooencyrtus anasae* Ashmead and *Anastatus* sp., both egg parasites. *Trichopoda pennipes* Fabricius was bred from the adult squash-bugs.

## SUMMARY

*Hadronotus ajax* Girault has been found to be a parasite in the eggs of the squash-bug (*Anasa tristis* DeGeer). The female parasite normally deposits a single stalked egg within the host egg. Hatching occurs within eighteen to twenty hours. In the course of development of the embryo, two embryonic membranes are formed; one is a cellular membrane, and the other is noncellular and is referred to as the hatching membrane.

There are three larval instars, each of which is terminated by a molt. The first-instar larva is teleaform, the second instar larva is sacciform, and the third-instar larva is hymenopteriform. The construction of a brown parchment-like cocoon marks the beginning of the prepupal stage. Larval life lasts five to six days.

The pupa stage occupies nine to ten days and is terminated by a pupal molt which just precedes emergence. Post-emergence remnants in the host egg are the cocoon, meconium, and the exuviae of the third-instar larva and of the pupa. The entire life cycle requires fifteen to sixteen days.

The species can reproduce parthenogenetically (arrhenotokous). The sex ratio, expressed as the sex factor, is 0.83, or one male to five females. Attempts at superparasitism were unsuccessful. The percentage parasitism was 23.0 percent for August, 1940, and 42.0 percent for August, 1941. There are at least four generations of the parasite per season. Each female produces an average of sixteen eggs. The calculated biotic potential was 31,290.

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## STUDIES OF THE GENUS EMPOASCA

(Homoptera, Cicadellidae)

### PART XI.<sup>1</sup> SIX NEW SPECIES OF EMPOASCA FROM MEXICO

RALPH H. DAVIDSON AND DWIGHT M. DeLONG,

Department of Zoology and Entomology,  
Ohio State University

#### *Empoasca irrita* n. sp.

Resembling *crocostigmata* but with different dorsal spine and lateral processes like *curvata* and *cerata*. Length 2.75–3 mm.

*External Characters*.—Vertex rounded, slightly produced, whitish in color except for an irregularly shaped golden area that surrounds an elongated white spot on the mid-dorsal line. Pronotum with irregularly shaped whitish areas on lateral and anterior margins, a golden colored central area which gradually darkens posteriorly to dark purple. Scutellum dark purple except for the anterior corners which are white. Fore wings with reddish brown to purplish areas on anterior commissural line, apices smoky. In well-marked male specimens a faint purplish spot appears on the costal margin and golden spot in the center of each fore wing. Female with last ventral segment almost truncate with rounded corners.

*Internal Male Genitalia*.—Lateral processes tapering gradually posteriorly, bent inwardly at about half their length and then curved outward ending with blunt pointed tips. Aedeagus long and slender with a rounded apex. Dorsal spine small, almost oblong in shape with the ventral anterior corner elongated into a sharp pointed tip.

Holotype male, allotype female, and a large series of male and female paratypes from Zitacuaro, Michoacan, Mexico (160 Km.)<sup>2</sup>, Sept. 29, 1941, collected by DeLong, Good, Caldwell and Plummer. Types deposited in the authors' collections.

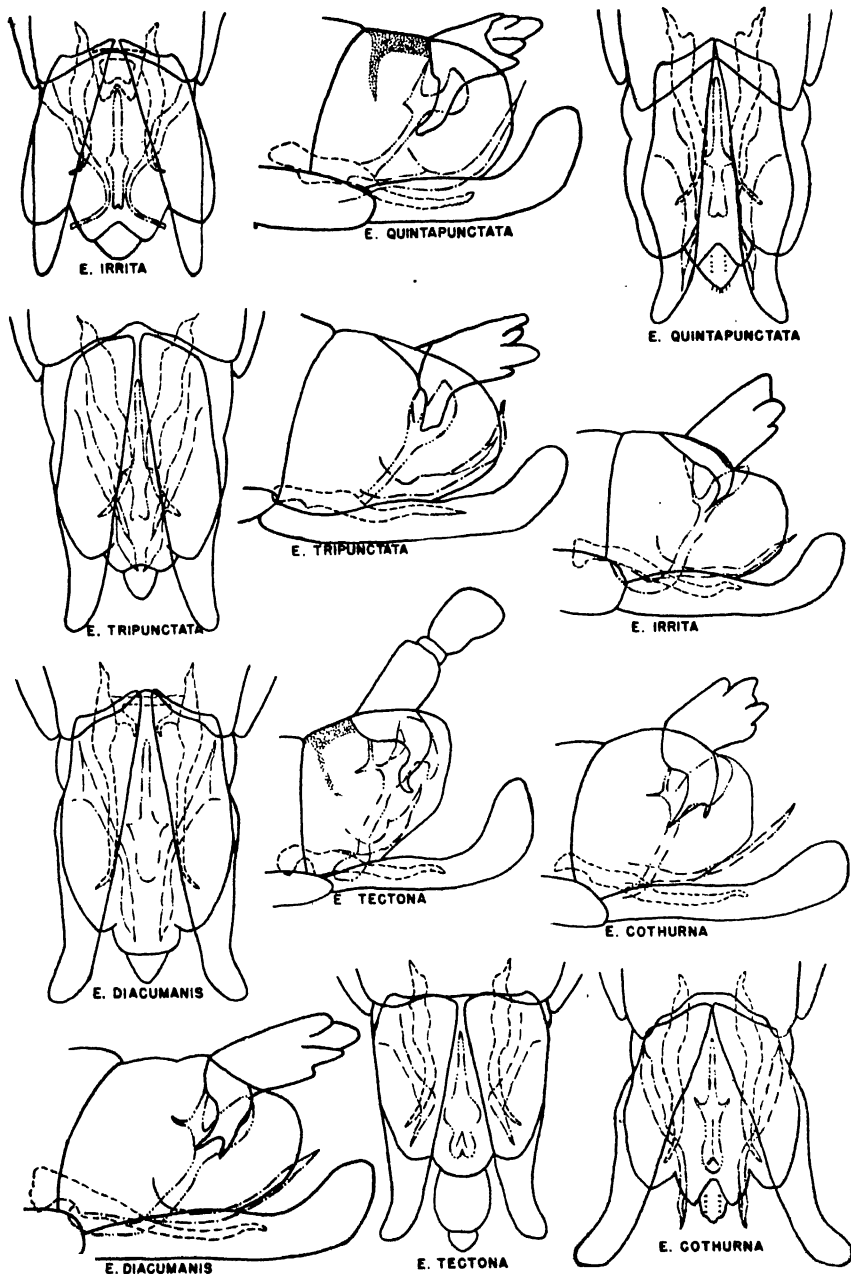
#### *Empoasca tripunctata* n. sp.

A long slender species with internal male genitalia resembling those of the *alboneura* group, but with characteristic dorsal spine and coloration. Length 4–4.5 mm.

*External Characters*.—Vertex golden to yellow with three black spots on anterior margin. Pronotum brownish centrally and posteriorly with greenish-yellow on anterior margin. Scutellum greenish-yellow with two faint longitudinal brown stripes. Fore wings

<sup>1</sup>Previous parts of this study have appeared as follows: Ohio Jour. Sci. 32: 393–401; 25: 29–39; 36: 225–230; 38: 90–96; 39: 110–118; 42: 12–126; 43: 214–220; and Ann. Ent. Soc. Amer., 27: 604–609; 33: 608–611; 35: 105–109.

<sup>2</sup>Kilometer figures following collecting localities indicate distances from Mexico City.



Ventral and lateral views of male genitalia of new species of *Empoasca*.

milky to subhyaline with brownish areas. Female with last ventral segment rounded and slightly produced.

*Internal Male Genitalia.*—Lateral processes long, directed inward and upward to dorsally pointing tips. In lateral view they appear enlarged just before they taper to the pointed tips. Aedeagus broad and rounded at the apex. Dorsal spine broad at base, narrowed to an oblong shape with the ventral anterior corner produced as shown in the accompanying illustration.

Holotype male, allotype female, and a female paratype from Guadalajara, Jalisco, Mexico (645 Km.), Oct. 3, 1941; male and female paratypes from Taxco, Guerrero (150 Km.), Oct. 26, 1941; Zitacuaro, Mich. (130 Km.), Oct. 5, 1941; Carapan, Mich. (432 Km.), Oct. 2, 1941; Tres Cumbres, D. F. Mexico (52 Km.), Oct. 21, 1941; all collected by DeLong, Good, Caldwell and Plummer. Types deposited in the authors' collections.

*Empoasca quintapunctata* n. sp.

Resembling *tripunctata* but larger in size and with different lateral processes, dorsal spine and five black spots on the vertex. Length 5 mm.

*External Characters.*—Frons and clypeus yellowish. Vertex yellowish posteriorly with five black spots on anterior margin, three of which are visible from above and the other two by tilting the specimen slightly. Ivory coloration predominates in the area between these spots. Pronotum deep reddish-brown with two faint medially located yellowish areas and two lateral whitish areas on anterior margin. Scutellum reddish-brown with two darker longitudinal stripes. Fore wings subhyaline with large reddish-brown areas, the extent of the coloration varying in different specimens. Female with last ventral segment rounded and very slightly produced.

*Internal Male Genitalia.*—Lateral processes stout, long, directed posteriorly then curving dorsally at about half their length and tapering gradually to very sharp-pointed tips. Aedeagus long, slender, with an enlarged dorsally-directed apex and a pair of anterior projecting pieces at base of enlargement which connect to the base of the dorsal spine. Dorsal spine long and slender, tapering slightly to a ventrally and inwardly curved, rounded apex.

Holotype male, allotype female, and a series of male and female paratypes from Zitacuaro, Mich., Mexico (130 Km.), Oct. 5, 1941; and Rio Frio, D. F. Mexico (55 Km.), Oct. 7, 1941, all collected by DeLong, Good, Caldwell and Plummer. Types deposited in the authors' collections.

*Empoasca diacumanis* n. sp.

Resembling species of the *alboneura* group but with characteristic coloration, dorsal spine and genital characters. Length 4 mm.

*External Characters.*—Frons and clypeus dark brown to black in color. Vertex of the same color but with four spots and the margin next to the eyes greenish-yellow. Pronotum dark brown centrally with yellowish-green antero-lateral margins. Scutellum with a dark

brown longitudinal stripe and greenish-yellow anterior corners. Fore wings with a greenish tinge, brownish spots, and smoky apices. Female unknown.

*Internal Male Genitalia*.—Lateral processes long, rather broad at base, then narrowed and curved slightly inward and upward, with slightly convexly enlarged outer margins just before the tapered pointed apices. These processes are almost identical with those of *ulrica*. Aedeagus long and slender with an enlarged rounded apex and a pair of anteriorly directed pieces near base of enlargement that connect to the broad base of the dorsal spine. The dorsal spine is ventrally directed and ends in a pair of short stout processes, the anterior one being the longer.

Holotype male and seven male paratypes from Puebla, Puebla, Mexico (78 Km.), Oct. 18, 1941, and Rio Frio, D. F. Mexico (47 Km.), Oct. 18, 1941, collected by DeLong, Good, Caldwell and Plummer. Types deposited in the authors' collections.

#### *Empoasca tectona* n. sp.

Resembling *resupina* somewhat in shape of lateral processes but with a distinct T-shaped apex on aedeagus. Length 3.5 mm.

*External Characters*.—General coloration lemon yellow to golden. Vertex rounded, slightly produced, with a broken median longitudinal white line and three white spots on each side. Pronotum with three irregularly shaped white spots on anterior margin. Scutellum with a median longitudinal white stripe and a spot of white on each of the anterior corners. Fore wings tinged lemon yellow. Female with last ventral segment roundedly produced.

*Internal Male Genitalia*.—Lateral processes, short, broad at base, then narrowed and directed inward, becoming enlarged again just before the divergent dorsally directed broadly pointed apices. In ventral view they resemble those of *sativa*. Aedeagus in ventral view constricted at apex like *stalsisa*. The apex in side view appears somewhat T-shaped. A pair of anterior projections near base of aedeagus enlargement connects to the base of the long, rather heavy dorsal spine which curves ventrally and inwardly.

Holotype male, allotype female, and a series of male and female paratypes from 12 miles south of Jacala, Hidalgo, Mexico, collected Sept. 26, 1941, by DeLong, Good, Caldwell and Plummer. Types deposited in the authors' collections.

#### *Empoasca cothurna* n. sp.

Resembling species of the *alboneura* group but with characteristic internal male genitalia and dorsal spine. Length 3.5 mm.

*External Characters*.—General coloration golden with pale blue markings on pronotum and fore wings. Vertex rounded with a median longitudinal white line and two lateral oblique dashes of white. Pronotum with three whitish spots on anterior margin, a median bluish longitudinal stripe, and a blue spot on each of the caudo-lateral margins. Fore wings golden with pale blue markings

and smoky apices. Female with last ventral segment rounded and slightly produced.

*Internal Male Genitalia*.—Lateral processes rather broad at base, narrowed at about one-third their length and curved inward and upward to tapered pointed apices. Aedeagus long and narrow with an enlarged apex which curves caudad and dorsad. A pair of anterior projections at the base of the enlargement connects to the base of the broad dorsal spine. The spine curves caudad and then ventrad, ending with a pair of processes, the anterior one being long and broad and the other quite narrow and shortened. In lateral view the spine has the appearance of a high-heeled boot.

Holotype male, allotype female, and a series of male and female paratypes from Tuxpan, Mich., Mexico (186 Km.), Oct. 5, 1941; and Tehuacan, Puebla, Mexico, Oct. 17, 1941, all collected by DeLong, Good, Caldwell and Plummer. Types deposited in the authors' collections.

ENTOMOLOGIA AGRICOLA DEL PERU, by JOHANNES E. WILLE, DR. PHIL.

Pages vii+468, 213 figures, 7 x 9 $\frac{3}{4}$  inches, paper bound. Published by LA ESTACION EXPERIMENTAL AGRICOLA DE LA MOLINA, Lima, Peru, Apartado 2791. 1943. Price, \$5.00, postpaid.

This is a very practical book on the agricultural entomology of Peru. It is written "for agriculturalists, students of agriculture, entomologists, and for all persons interested in agricultural entomology."

The plan of the book is somewhat like that of Metcalf and Flint's "Destructive and Useful Insects." Following a short preface outlining the work of the Experiment Station, and an introduction discussing the economic importance of insects in Peru, there are separate chapters on the insects which attack various agricultural crops: (1) insects which attack cotton; (2) insects which attack sugar cane; (3) insects which attack cereals (rice, wheat, and corn); (4) insects which attack cultivated tropical plants (coffee, cocoa, tea, tobacco, etc.); (5) insects which attack orchards and vineyards (citrus trees, olives, figs, apples, peaches, grapes, etc.); (6) insects which attack field and garden crops (legumes, tomatoes, various other garden crops, and ornamental plants); (7) insects which attack various other cultivated plants (sweet potatoes, flax, pyrethrum, alfalfa, etc.); (8) insects which attack stored grains and seeds; and (9) a summary of insect control measures (cultural, biological, physical, and chemical). At the end of the book is a bibliography of 131 titles (which is frequently referred to through the book), a glossary, and an index.

The accounts of the various insect pests are quite detailed. For each species or type of insect treated, there is a general account of the pest problem and the damage done, a description of the insect and an account of its life history and habits, often a discussion of its parasites and predators, and a discussion of its control. The book is well illustrated with drawings and photographs of the various insects (adults and immature stages) and the damage they do, and occasional figures illustrating control measures.

This book marks an outstanding step in the progress of economic entomology in Peru. Up until about 1929, most of the entomological research of the Experiment Station had to do with the insects attacking cotton and sugar cane, but since that date the work of the Station has expanded, and research has been carried on with the insects attacking other crops. This Experiment Station has put out a large number of excellent publications in recent years, in the form of *Circulares*, *Informes*, *Boletines*, and *Memorias*. The present excellent volume is typical of the entomological work now being done in Peru.—D. J. B.

# NOTES ON THE NESTING HABITS OF CERTAIN SOCIAL AND SOLITARY BEES OF MEXICO

PHIL RAU,  
Kirkwood, Missouri

These fragmentary notes on social and solitary bees of Mexico were made during two trips of about a month each, February, 1939 and July, 1940, to that country. Other observations on the habits of certain Aculeate Hymenoptera, made during these visits, have been published in the Annals of the Entomological Society of America, 33: 81-94, 590-595, 1940, and 36: 515-536, 1943.

## STINGLESS BEES

### ***Trigona (Partamona) testacea* var. *orizabaensis* Strand** (Herbert F. Schwarz)<sup>1</sup>

Colonies of these social bees were observed at Cordoba, V. C., Jalapa, V. C., Tamazunchale, S. L. P., and Iguala, Gro. Some nests were under bridges, some in culverts under the highway, and others in niches and crevices in ruined buildings. All but one were in vertical positions; the exception lay horizontally on top of a lumber pile in an open-faced shed.

The nests are usually built in some man-made structure, and while often a large portion of the nest is exposed to the weather, the important portions—the brood cells and many of the provision vats—are always deep within the recesses of the walls, amply protected from the elements and from prowling enemies.

The colonies are not annual affairs, and certain ones which I marked in February were still active in July a year and a half later. Apparently, the bees are active at all times of the year; this may not seem surprising, since these bees are found only in the tropical portions of Mexico; but we must not lose sight of the fact that in these very same regions certain social wasps do not have all-year-round activity, but spend a period in rest during portions of the dry season (Ann. Ent. Soc. Amer. 33: 81-94, 1940).

Some species of *Trigona* bees build a tube before the opening of the nest, but this species makes massive structures of cerumen resembling very much those of *Trigona cupira* of Panama (see figs. 1 and 4, Jungle Bees and Wasps of Barro Colorado Island), excepting that the opening to the nest of the Mexican species is at the bottom. Figure 1 (about  $\frac{2}{3}$  natural size) illustrates the outside wall of *T. orizabaensis*. The nest is dung-colored, and often blends beautifully with its ancient surroundings; it is hard and brittle in texture. The cerumen of which it is made is a mixture of wax manufactured by the bees and foreign substances such as dirt, dung and resins. Fig. 1 (above the arrow) shows the large

<sup>1</sup>The names of the experts who have kindly identified the material appear in parentheses.

oval opening in the lower right-hand corner, and at the top of this a half-dozen or so smaller openings. From all of these doorways the bees, with their sticky legs, biting jaws and crazy crawling, pour forth at the slightest disturbance, and like other stingless bees, crawl into your ears, eyes, hair and neck, where they can quickly drive you frantic by biting you and dragging their filthy, rasping legs over your skin. The openings of the nest are abundantly supplied with guards who apparently have a way of communicating to the hordes inside the wall in the event of danger. Fig. 2 (also about  $\frac{3}{8}$  natural size) shows the inside of the nest (the reverse of fig. 1) full of nooks and crannies which give shelter to several thousands of bees, all within easy reach of the openings.

This nest had several storage vats for pollen and honey deep in the recesses of the stone wall and a few among the crevices of the wall of cerumen not shown in the photograph. Evidently the honey of these bees is attractive to the natives of Mexico, for someone had placed at the entrance of a nest in a ruined wall near Jalapa a home-made funnel of heavy card-board. This funnel must have been there for some time, for the bees had covered portions of it with cerumen. The honey stores were about ready for tapping, for when I removed the funnel (net over face and hands fully gloved), I broke into large vats of honey which flowed abundantly down the wall. The removal of the funnel gave direct access to several thousand adult bees, and also the brood combs, probably a dozen in number, round in shape and about three inches in diameter, resembling very much the combs of *Trigona dorsalis* figured on page 30 of *Jungle Bees and Wasps*. By placing the card-board at the opening, the natives had evidently prevented the bees from making the usual outside structure.

### ***Trigona pectoralis* Dalla Torre (Herbert F. Schwarz)**

A large colony of these red stingless bees nested so deep in a wall of an ancient ruin at Cordoba, V. C., that they were safe from my intrusion. They reached their nest through a hole in the wall about a half-inch in diameter. Over this hole they had built a horizontal tube of yellowish-red wax (which incidentally resembled their own coloration), one and one-half inches in length and three-fourths inch in diameter, which harbored many guards.

### ***Trigona mexicana* Guerin (Herbert F. Schwarz)**

Several nests of this species were seen attached to the limbs and trunks of trees along the shores of the River Amajac near Tamazunchale, but none were within reach for study.

### EXPLANATION OF PLATE

FIGURE 1. Outside wall of nest of *Trigona orizabaensis*, about two-thirds natural size. 2. A view of the inside of the nest, the reverse of figure 1, about two-thirds natural size. 3. Nest of *Polistes instabilis*, about natural size, showing a large number of cells resealed with resin by *Megachile peruviana* in the right third of the photograph. At *a* are six cells sealed with mud by *Stenodynerus mysticus*, and in the third and fourth cells under *d*, the cells of the leaf-pulp wasp, *Zethus pipens*. The second cell under *d* is unique in having in the center of a mud plug the seal of leaf pulp, showing that the cell had been used successively by *S. mysticus* and *Z. pipens*. At *c* is a group of cells covered with silky web, the work of the parasitic lepidopteron, *Chalcoela iphitalis* Walk.





## SOME SOLITARY BEES

**Megachile peruviana** Smith (T. B. Mitchell)

Megachile bees are generally known as leaf cutters, for they fashion their brood-chambers from discs which they cut from leaves and flower petals, but *M. peruviana* works in resin. These bees do not make nests of their own, nor do they fashion any brood pots, but they appropriate the old nests of paper wasps, and by building partitions and plugging the openings of the cells with a resinous substance they convert them into satisfactory brood chambers for their young.

Dr. T. B. Mitchell, who has kindly identified these bees, writes that the resin-working Megachilid bees belong to the subgeneric group *Chelostomoides*, and that there are interesting morphological characters in both groups which seem to support the observations on behavior, the resin-gatherers lacking, in the females, the beveled cutting edge of the mandibles which is so characteristic in the species which cut leaves.

There is but little known on the habits of the resin-gathering Megachilid bees, and Dr. Mitchell writes further that the first reference in this country to this habit is on *M. campanulae*, (Rau, Trans. Acad. Sci. St. Louis 25: 157-277, 1926), and a year later Hicks published a note on the resin-using habits of *M. subexilis* (Ent. News 38: 17, 1927). A few years previously, however, two or three species belonging to the subgenus *Hackeriapis* in Australia were found to have similar habits. In this connection it is interesting to note a remark by Tarlton Rayment (A Cluster of Bees, p. 444, 1935) to the effect that Mr. Hy. Hacker in Australia has actually seen both sexes of *Megachile rhodura* scraping resinous material from a wound in the bole of a Eucalyptus tree.

But to return to our species *M. peruviana* in Mexico: the bees were found occupying two old paper nests of *Polistes instabilis* (fig. 3) and one old paper nest of *Mischocyttarus* sp. These nests were hanging vertically in culverts under the highway between Iguala and Mexcala, Gro. Close neighbors in one of these nests were two species of wasps, *Zethus pipens* (fig. 3, b and d) and *Stenodynerus mysticus* (fig. 3, a), the former plugging the old cells with chewed-up green leaf material, and the latter with mud.<sup>2</sup>

*M. peruviana* uses resin both for plugs for the doorways and for partitions within the cell. The mother bee places but one young in each cell. Each cell has a vestibule or air-space, which is formed by placing a thin wall of resin about one-fourth inch from the opening leaving the brood-cell back of this space. In fig. 3 may be seen a nest of *Polistes instabilis* with many of its cells resealed with resin. Incidentally, others are there sealed with leaf pulp or mud; these are the work of the two species of wasps already mentioned.<sup>3</sup>

The surfaces of the resin plugs are not smooth, but are lumpy and

<sup>2</sup>Toward the left in fig. 3 at c, are several covered cells containing the parasitic Lepidopteron, *Chalcoela iphitalis* Walk., and the second cell below b (a mud plug with a leaf-pulp center) is the work first of *S. mysticus* and later, *Z. pipens*.

<sup>3</sup>An account of these wasps appears in Ann. Ent. Soc. Amer., 36 (3): 515-536, 1943. *M. peruviana* was mentioned in this account as a new species; however it proved to be not a new species, but *M. peruviana*.

rough, and portions of it are often irregularly placed, sometimes piled high above the rim of the cell. The bees evidently get the resin from several sources, for the plugs are made up of material of various colors, sometimes different colors appearing in one plug; various shades of browns and grays, and delicate greens and ambers. Some of the plugs glisten in the light, and this probably is due to bits of hardened saliva which go into the manufacture of the substance. There is sufficient indication, however, that each mouthful of the material has been thoroughly worked over in the jaws of the maker. Sometimes the plugs are very thin, and again they may be as much as one-fourth inch in thickness. The brood cells are about three-eighths inch in length by three-sixteenths inch in diameter; their walls are varnished with a dark brown, glossy substance which is evidently added by the larvae before pupating, but I have never been able to find if this is a secretion from the mouth or excrement from the anus.

In one of the nests (fig. 3) fifty-three cells were sealed with this resinous substance, and from some of these cells in my laboratory at Kirkwood adults of this species emerged between October 11 and 13, 1940. From an old *Polistes* nest, similarly sealed, taken at Jalapa, V. C., I removed a few dead immature adults which, according to Dr. Mitchell, were also *M. peruviana*.

This bee is not free from parasites. From the resin-sealed cells in the nest of *Mischocyttarus* sp., several Chalcid parasites (*Monodontomerus mexicanus* Gahan)<sup>4</sup> emerged, and from one of the cells sealed with resin in the nest illustrated I removed several dead Chalcid parasites, *Monodontomerus montivagus* Ash. (A. B. Gahan).

**Megachile exilis** Cress. (K. V. Krombein)

An adult emerged July 26, 1940, from a resealed cell in a nest of *Polistes exclamans* taken at Artesian Wells, Texas. The locality is so near the Mexican border that the note is included here.

**Diceratosmia azteca** Cress. (K. V. Krombein)

An adult was taken from my laboratory window; evidently it had escaped from some of the nests brought home from Mexico.

**Stelis costalis** Cress. (K. V. Krombein)

This bee, evidently a parasite, emerged from a nest of the mud-dauber *Sceliphron* sp., taken at Mission, Texas, on the Mexican border.

**Nomia nortoni** Cress. (K. V. Krombein)

One specimen flew into the car at Texcoco, near Mexico City, on July 22, 1940.

**Agapostemon coloradensis** Vach. (K. V. Krombein)

Several bees were going to the flowers of a cactus at Zimapan, Hdgo., July 9, 1940.

<sup>4</sup>This is a new species recently described by Mr. Gahan in Proc. U. S. Nat. Museum, 90: 468, 1941.

*Centris lanipes* F. (K. V. Krombein)

Two dead bees of this species were found in sealed cells of *Scaliphron assimilis* taken at Acapulco, Gro. This bee does not use the old cells as they are found, but actually makes new cells of mud within the old ones.

*Xylocopa brazilianorum* L. (K. V. Krombein)

These carpenter-bees were busy at flowers at Cuernavaca, Morelos, in February, 1939, and also were nest-building at Pie de la Cuesta, Gro., in July, 1940. They were excavating their tunnels in the horizontal bamboo poles of a hut, and brushing the golden wood dust to the ground. A large number of poles in the roof were being worked in this manner, and many bees were seen going into these tunnels heavily laden with pollen. When opened, these tunnels proved to be from six to eight inches in length and about five-eighths to three-fourths inch in width. Like our local *Xylocopa virginica*, this species is gregarious, for from four to six adults were found in each of the several tunnels. Cells were made by partitioning the tunnels with walls of agglutinated saw-dust. In one such tunnel, two cells had masses of bee-bread. In all these details of nesting, this species differs in no wise from our own *X. virginica*.

There is a dipterous insect (a syrphid fly) which I have often met which mimics *X. brazilianorum* so skillfully that it has often deceived me. It resembles the bee not only in appearance but in buzz and in movements also. *Xylocopa* has the habit of bobbing up and down before entering the nest, and I have often seen this syrphid hovering in the identical way before a blank wall in the culverts under the highway. This fly, *Volucella mexicana* Marc. (C. T. Greene) was taken at the Teotihuacan pyramids near Mexico City, and at Santa Engracia, Tamps.

Since our own *X. virginica* hibernates gregariously as adults, and since *X. brazilianorum* were active on the wing at Cuernavaca in February, one wonders whether those in Mexico have a twelve-month period of activity, or whether they also go through a period of hibernation.

VIRUS DISEASES, by members of the Rockefeller Institute for Medical Research: THOMAS M. RIVERS, WENDELL M. STANLEY, LOUIS O. KUNKEL, RICHARD E. SHOPE, FRANK L. HORSFALL, JR., and PEYTON ROUS. Pages ix+170, 24 figures, 6¼ x 9½ inches. Published by CORNELL UNIVERSITY PRESS, Ithaca, New York. 1943. Price, \$2.00.

This book contains the six Messenger Lectures given at Cornell University in the spring of 1942: Virus Diseases with Particular Reference to Vaccinia, by Thomas M. Rivers; Chemical Structure and Mutation of Viruses, by Wendell M. Stanley; New Hosts as a Key to Progress in Plant Virus Disease Research, by Louis O. Kunkel; Swine Influenza, by Richard E. Shope; Human Influenza, by Frank L. Horsfall, Jr.; and Viruses and Tumors, by Peyton Rous.

Much has been learned about viruses in the last fifty years, and their importance as the cause of many important diseases of man and animals is widely recognized. This book will not have much practical value for entomologists investigating the problems of insect transmission of virus diseases, but it should be of interest to all interested in the subject. It presents a clear, concise account of what is known of certain phases of this problem.—D. J. B.

# THE NESTING HABITS OF CERTAIN SPHECID WASPS OF MEXICO, WITH NOTES ON THEIR PARASITES

PHIL RAU,  
Kirkwood, Missouri

This is the tenth and last paper on Mexican insects, all of which are the outcome of two brief trips to that country in 1939 and 1940. The titles of the other nine appear at the end of this article (p. 653).

Mexico is full of delights for the student of nature. Its rich insect fauna and its extreme climatic variations offer endless material for biological studies. One may pause in a tropical lowland and look up through palm and banana leaves at the perpetual snow above the mountain pines; or in a mere half-hour on a smooth road one may pass from desert to rain-forest, or from tropics to alpine meadows. That it should become a Mecca for outdoor naturalists is at once evident when one considers that all the data in these papers were gathered in a period of about six weeks.

Also, the sprinkling of references to new species shows to the restless taxonomist what Mexico has to offer in his line. To give a concrete example: of three specimens of Myriapods picked up only incidentally, and not mentioned in any of the papers, all were, according to Dr. R. V. Chamberlin, new to science.<sup>1</sup>

All in all, a place is seldom found which holds so much near at hand for the interested student.

## WASPS

### *Sceliphron assimile* Dahl [K. V. Krombein]<sup>2</sup>

In my paper on "Mud-daubing Wasps and Their Parasites," (Ann. Ent. Soc. Amer. 33: 590, 1940), I called certain wasps *Sceliphron caementarium*. So familiar did they appear to me that I did not even collect specimens to send to the taxonomic specialist for verification. However, as the months rolled by the guilt in my heart and the remorse in my head grew heavy, so on the second trip I was glad of the opportunity to do penance by collecting specimens of this yellow-legged mud-dauber in the several localities mentioned before. To my chagrin, Dr. Krombein pronounced all of them *S. assimile*. Therefore in the aforementioned paper, all of the wasps called *S. caementarium* should be corrected to *S. assimile*.

In addition to the localities cited in that paper, specimens and their nests were taken at Pie de la Cuesta and Acapulco, Gro., and at Santa Engracia and Limon, Tamps., and Jalapa, V. C.

<sup>1</sup>These are *Messicovolus rauli*, *Rhyssodesmus potosianus* and *R. cuernavacae*, and are described by Dr. R. V. Chamberlin in Bull. Univ. Utah, Biol. Ser., 6: 13, 1941, and Canad. Ent., 1942.

<sup>2</sup>The names of the experts who have kindly identified the material appear in brackets.

I am not sure how many generations these wasps produce each year, but our limited evidence indicates that their routine is the same as that of our temperate species, *S. caementarium*. Several hundred wasps emerged between July 10 and August 5 from the nests collected; this lot evidently would have produced the generation to hibernate.

**Chalybion zimmermanni** Dahl [K. V. Krombein]

This species is evidently a cuckoo wasp, using the cells of *S. assimile* in the same manner as *C. caeruleum* which breaks into the nests of *S. caementarium*.

Many specimens of *C. zimmermanni* emerged from cells in the nests of *S. assimile*; these cells had been resealed with mud or white plaster. This wasp was found in all of the localities where *S. assimile* lived, but was found nowhere independent of that species. In addition to the localities recorded for this wasp in the aforementioned paper, it was taken at Jalapa, V. C., and Jacala, Hdgo. From nests taken at the two latter localities, adult wasps emerged July 18 and 25, and others gave forth their adults between August 12 and 20.

**Chlorion harrisi** Fern [K. V. Krombein]

A large number of these grass-carrying wasps were nesting in the hollow stems of a thatched roof at Santa Engracia, Tamps. They have a wide distribution, are found in Missouri, and their life history has been recorded in Bull. Brooklyn Ent. Soc. 30: 65-68, 1935. Their behavior in Mexico is very similar to that here. At the time of my observation, noon on July 5, they were going through a courtship dance in several groups of 20 to 25 individuals, in front of the sloping roof of the hut. None of them were bringing in strands of grass, nor were they bringing in prey, but the openings of many bamboo canes in the roof were sealed with heavy plugs of dried grass.

**Chlorion (Isodontia) costipennis** Spinola [K. V. Krombein]

Several wasps were seen foraging among the flowers of a red milk-weed at Limon, Tamps., July 20, 1940.

**Podium iridescent** Kohl? [K. V. Krombein]

Several were at the flowers of a red milk-weed at Limon, Tamps., July 20, 1940.

**Stizus godmani** Cam. [K. V. Krombein]

A pair taken in copula on a cactus plant near Zimapan, Hdgo.

**Passaloecus pusillus** Sauss.? [K. V. Krombein]

The wasp *Trypoxylon* sp. (in *fabricator* group) fashions delicate cells of mud which she fills with tiny spiders. After they become vacant, the aphid-hunter wasp, *P. pusillus*, appropriates them for her young. After she has provisioned the cell with aphids, and deposited her egg, she seals up the opening, not with mud, but with a transparent, glass-

like substance. In some of the cells the partitions were made of this same material.

Two such mud nests that had been re-used by this tiny wasp were removed from the wall of a culvert near Acapulco. Some of the cells when broken open were found to contain dead adults of *P. pusillus* (one in each of several cells), while others held dead plant-lice, six to eight in a cell. The plant-lice were *Aphis gossippi* [P. W. Mason], *Macrosiphum* sp. [P. W. Mason] and *Aphis* sp. belonging to the *Aphis rumicis* L. group [P. W. Mason].

This little wasp has its parasites, for there were present in some of the cells dead adults of two species of Chrysididae: *Omalus* near *diversus* Oar [K. V. Krombein] and *Chrysis* near *verticalis* Patt. [K. V. Krombein], while in another cell were several dead Chalcid parasites which proved to be new to science, *Monodontomerus* n. sp. [A. B. Gahan], (my number 2486).

#### **Trypoxylon** sp., group **fabricator** [K. V. Krombein]

As related above, this species makes clusters of small, delicately formed mud cells against flat walls. The cells measure but a half-inch in length, and are only one-eighth inch wide. This means that both the occupants and the prey in such a tiny domicile must themselves be very small. The clusters of cells are finally daubed all over with mud, so their graceful contours are obliterated.

Two of these nests were found on the walls of a culvert near Acapulco; they had about twenty cells in each. From these, six adults emerged between July 20 and 30. The abandoned cells of this wasp have been used by the aphid wasp, *P. pusillus*, as recorded above.

#### **Trypoxylon tenocitlan** Richards [K. V. Krombein]

Many wasps of this species were nesting in the bamboo poles of a hut near Mexcala, Gro., on July 11.

#### **Trypoxylon**, near **nitidum** Sm. [K. V. Krombein]

An old paper nest of *Polistes instabilis* taken near Acapulco, Gro., had two cells resealed with mud. A dead wasp of this species was found in each of these cells.

#### **Trypoxylon salti** Richards [K. V. Krombein]

One adult emerged from a nest of *Sceliphron assimile* in July. The nest was taken at Tamazunchale, S. L. P.

#### **Trypoxylon mexicanum** Sauss. [K. V. Krombein]

May I add to the notes already published (*loc. cit.*, p. 592) that their date of emergence is between July 15 and 25; a dozen wasps emerged at that time from nests collected at Jacala, Hdgo.

At the same time, I saw a mother *T. mexicanum* storing spiders in another nest. From two and one-half cells I removed the following spiders: 5 females of *Eustala anastera* Walck. [E. B. Bryant] and 5 females and 18 immature individuals of *Neoscona orizabensis* Cambridge [E. B. Bryant].

***Trypoxylon texense* Sauss. [K. V. Krombein]**

In addition to the locality records already published (*loc. cit.*, p. 592), nests of *Sceliphron* sp. taken at Santa Engracia, Tamps., and at Mission and Rio Grande City, Texas, harbored *T. texense*. Many adults emerged between July 5 and 20. At Rio Grande City a mother was seen carrying spiders to the nest; these were four males of *Ashya minuta* Cambridge [E. B. Bryant] and several immature *Misumenops* sp. [E. B. Bryant].

***Trypoxylon* sp., near *palliditarsus* Sauss. [K. V. Krombein]**

Figures *b-e*

This species is the largest *Trypoxylon* that I have ever seen. Dr. Krombein says that it belongs to the *politum* (= *albitarse*) group, and is probably a new species, close to *palliditarsus* but quite distinct from it. It was found in only one place in our Mexico collecting.

Some mud-wasps make their pipe-organ nests with great precision and neatness (i. e., *T. politum* at *a* in Plate I; approximately natural size<sup>a</sup>), but these make them large, rough and coarse, as may be seen in figs. *b*, *c*, *d* and *e*. The unit of mud used in the construction seems almost too large to be carried by the mouth; one wonders if the legs are brought into use in the transporting of it. Most of the nests comprised three to five tiers of cells, or parallel "pipes," although one had only one tier when found. The pipes (fig. *c*) were from two to six inches in length and were partitioned with mud, each making from one to five cells of an inch to an inch and a quarter in length and three-fourths to an inch in width (fig. *e*). The thickness of the walls varied from one-half to three-fourths inch. The nests, found in a culvert under the highway between Chilpanzingo (which, incidentally, is Aztec for "wasp's nest") and Ocolito, Gro., gave forth their adults in early August. An effort was made to locate other nests in the vicinity, but none were found.

The cocoons are rough, brown and brittle, and resemble very much (except in size) those of *P. politum* (= *albitarse*). It is probably made from the accumulated excrement that passes from the body when the larva has finished feeding. In several cells were large, dead spiders.

From one of the cells a bee, *Hylaeus* sp. [K. V. Krombein] emerged on July 20. This bee probably uses the cells only for a nesting place and is not parasitic. However, two species of parasites did emerge from the cocoons in early August, a dipterous parasite *Epogostylum oedipus* F. [C. T. Greene] and a Chalcid wasp, *Monodontomerus montivagus* Ash. [A. B. Gahan].

<sup>a</sup>The nest of *T. politum* was included for comparison.

#### EXPLANATION OF PLATE

*a*, Nest of *Trypoxylon politum* of Missouri, placed in plate for comparison. Approximately natural size. *b* and *d*, the outside of nests of *T. sp.* near *palliditarsus*, showing the rough layers of mud and the holes made by emerging adults. Approximately natural size. *c* and *e*, the under side of nests of *T. sp.* near *palliditarsus*; *c*, the gallery before partitions are made, and *e*, a gallery with three cells. Approximately natural size.





## PARASITES

**Exoprosopa capucina** F. [C. T. Greene]

One fly (Bombyliidae) emerged, July 20, from a nest of *Sceliphron assimile* taken at Jacala, Hdgo. It appears that there may be more than one generation a year of this fly, since previously (*loc. cit.*, p. 595) they emerged from similar nests in May and June.

**Senotainia** sp. [D. G. Hall]

Two flies of this species (Sarcophagidae) emerged on August 25 from nests of *Sceliphron* sp. taken at Devine, Texas, and two others emerged on July 28 and 30 from nests of *S. assimile* taken at Hidalgo, Hdgo.

**Leucospis** sp. [A. B. Gahan]

A dead specimen of this hymenopteron was taken from a mud nest at Acapulco, Gro.

**Chrysis (Trichrysis) parvula** F. [K. V. Krombein]

One cuckoo wasp emerged on July 30 from a nest of *S. assimile* taken at Hidalgo, Hdgo.

**Chrysis (Tetrachrysis)** sp. [K. V. Krombein]

Two cuckoo wasps emerged in mid-July from *Sceliphron* nests taken at Acapulco, Gro. and Victoria, Tamps., and one emerged from a mud-capped cell (probably a *Trypoxylon* cell) in a *Polistes* nest taken at Mexcala.

**Macrosiagon** sp., probably **excavatum** Champion [H. S. Barber]

Mud nests were collected in several places in Mexico, and the lot from each locality was placed in separate cloth bags. When examining the contents of the bags after returning home, I found in one bag labeled Santa Engracia, Tamps., eight dead individuals of this parasitic beetle that had emerged from mud nests en route, and a live one in one of the cells ready to emerge.

These beetles are members of the family Rhipiphoridae, whose members are parasitic on wasps, but whose life history is still for the most part unknown. There is no doubt that the beetles spend their immature life within the mud cells, but whether they are parasitic on *Sceliphron assimile*, *Chalybion zimmermanni*, *Trypoxylon texense* (all three of which emerged from these mud nests), or on the spider prey within the cells, is not known. Imms (Textbook of Entomology, p. 499, 1925) says that one species of Rhipiphoridae, *Metoecus paradoxus*, is a parasite in the nest of the social wasp *Vespa vulgaris*, and members of the genus *Emenadia* utilize *Odynerus* wasps as hosts, while Fabre found the larvae and pupae of another Rhipiphorid (Sharp, Insects, Pt. II, p. 269, 1899) in the cells of the solitary bee, *Halictus sexinctus*. The most remarkable of the Rhipiphoridae, according to Sharp, is *Symbius blattarium*, which is parasitic on cockroaches.

It seems to me that anyone working in the vicinity of Santa Engracia should make an effort to study the early life history of this beetle in the nests of mud wasps, for it is not known just how the parasitism takes place. Sharp says (*loc. cit.*, p. 208) apparently the eggs are not deposited in the nests of the wasps, but in old wood; the young larva is a triungulin, similar to that of the Cantharidae, and it is possible that when the wasp visits the old wood haunted by the larvae, some of them attach themselves to it and are carried to the wasp's nest. It seems that the life history could easily be worked out in the laboratory if a supply of live beetles could be obtained, for the hosts—the wasp larvae—are easily obtained in any season.

#### LIST OF PAPERS ON MEXICAN INSECTS

1. The nesting habits of several species of Mexican social wasps. *Ann. Ent. Soc. Amer.*, 33: 81-93, 1940.
2. The mud-daubing wasps of Mexico and their parasites. *Ibid.*, 33: 590-595, 1940.
3. Observations on certain Lepidopterous and Hymenopterous parasites of *Polistes* wasps. *Ibid.*, 34: 355-366, 1941.
4. The monarch butterfly, *Danaus plexippus*, in Mexico. To appear in *Entomological News*.
5. The nesting habits of the Mexican bumblebee, *Bombus medius*. *Psyche*, 48: 166-169, 1941.
6. Clouds of butterflies in Mexico; a study in butterfly aggregations. *Ent. News*, 53: 121-126, 151-155, 181-184, 1942.
7. The nesting habits of Mexican social and solitary wasps of the Family Vespidae. *Ann. Ent. Soc. Amer.*, 36: 515-536, 1943.
8. Notes on the nesting habits of certain social and solitary bees of Mexico. *Ann. Ent. Soc. Amer.*, 36: 641-646, 1943.
9. The sleep of *Chalybion zimmemanni*. *Canadian Ent.*, Oct., 1942.

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THE AMATEUR SCIENTIST, by W. STEPHEN THOMAS. Pages 291, 5½ x 8 inches, illustrated. Published by W. W. NORTON AND CO., INC., New York, N. Y. 1942. Price, \$3.00.

The author of this book is Executive Secretary of the Committee on Education and Participation in Science, which for the past two and a half years has been studying amateur science in the Philadelphia area. The book deals with the data obtained by this committee, and the conclusions to be drawn therefrom.

There are thousands of people in the country who are studying some phase of science as a hobby, and it is this group which the author describes—their normal occupations, their reasons for pursuing their hobby, their organizations, the problems on which they work, and their relationships to the professional scientist. Many scientific fields, including entomology, are represented in the interests of this group. The amateur scientists serve as a link between the professional scientist and the general public, and the work of the individual amateur or of his organization often contributes materially to the advancement of scientific knowledge. Four sample programs for amateur research in the Philadelphia area are described in some detail, including one on marking and tagging various animals other than birds.

This book will probably open the eyes of some entomologists to the scope of amateur participation in science. Entomology would certainly profit by entomologists encouraging the study of insects by interested amateurs.

This book is well written and interesting. It is one we would recommend as an excellent gift for a scientist friend.—D. J. B.

# A NEW GENUS, ARTUCEPHALUS, AND A NEW SPECIES OF MEXICAN LEAFHOPPER

(Homoptera, Cicadellidae)

DWIGHT M. DELONG,

Ohio State University,  
Columbus, Ohio

Among other forms of leafhoppers taken in the State of Guerrero, Mexico, this is one of the interesting species which superficially resembles some of the southwestern leafhoppers, but which apparently belongs to an entirely different genus.

## Genus *Artucephalus* nov.

Probably allied to *Aligia*. The vertex is very short, slightly produced, broadly rounded, almost parallel-margined, more than twice as wide between eyes at base as median length and with a sharp margin and angled with the front. The whole insect appears broad and wedge-shaped. The face is broad, almost straight from apex of vertex to clypeus. Elytra with only one regular cross vein in the second sector, but with supernumerary cross veinlets near the base. Middle portion of clavus with supernumerary cross veins. Several costal veinlets are present, especially in the region of the first anteapical cell. Genotype, *Artucephalus fasciatus*, n. sp.

## *Artucephalus fasciatus* new species

In general appearance resembling a banded species of *Aligia*, but with a distinct vertex and male genitalia. Length 6 mm.

Vertex short and broad, only slightly produced and broadly rounded, almost parallel-margined, more than twice as wide between eyes at base as median length. The margin angled with the front.

*Color*.—Vertex yellow tinged with orange, a round black spot next to each eye, just above ocellus. A pair of elongated spots beneath margin at apex, just visible from above, and another elongated spot on each side between these and ocellus. Pronotum orange to brown, the posterior margin broadly white. Scutellum orange brown, a yellow margin on sides of apical angle. Elytra appearing dark brown, paler at base, and with a broad conspicuous white transverse band across middle. Several white spots along apical costal area and at base of apical cells.

*Genitalia*.—Male plates rather narrow, triangular, distinctly exceeded both laterally and apically by the pygofer. Style long and slender, almost as long as plate, apical sixth bent slightly outwardly. The aedeagus is erect and Y-shaped, the basal branch of the "Y" is decidedly shorter than the caudal branch. In ventro-caudal view the basal branch is wide and the caudal branch is much narrower and

cleft. The pygofer spines are unique, being large, thick, almost plumose, arising on the inner margin near the base and extending more than two-thirds the length of the pygofer.

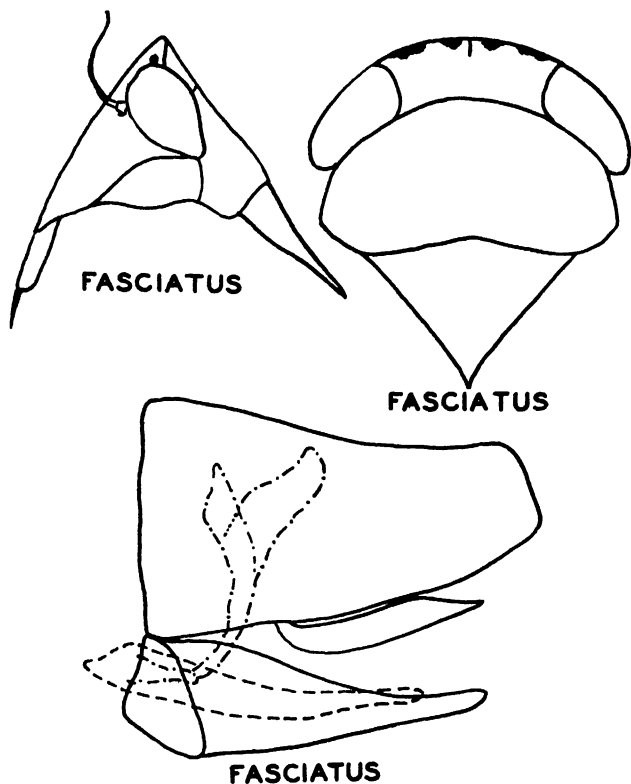


FIGURE 1. *Artucephalus fasciatus*, n. sp. Lateral and dorsal views of head, pronotum, and scutellum (upper figures); and lateral view of male genital structures (lower figure).

Holotype male and paratype males from Iguala, Guerrero, Mexico, elevation 2398 ft., collected September 11, 1939, and October 25, 1941, by Dr. C. C. Plummer, E. E. Good and the author. Type material in the author's collection.

STUDIES ON HOST PLANTS OF THE LEAFHOPPERS OF THE GENUS EMPOASCA, by F. W. POOS AND NANCY H. WHEELER. Tech. Bul. No. 850, U. S. D. A., May, 1943, 51 pp., 21 figs.

The actual and potential importance of empoascan species from the economic standpoint is emphasized in these studies by the wide variety and large number of host plants from which many species were reared. The indiscriminate *Empoasca fabae* (Harris) was reared from no less than 108 host plants. Approximately 50,000 male specimens of *Empoasca* were identified specifically but the females remained anonymous.—DOROTHY J. KNULL.

# ON THE CLASSIFICATION OF NEOTROPICAL MEGACHILE

(Hymenoptera: Megachilidae)<sup>1</sup>

THEODORE B. MITCHELL,

University of North Carolina,  
Raleigh, N. C.

After completing the publication of the Revision of Nearctic Megachile<sup>2</sup> in 1937, it was intended to continue the taxonomic investigation of this group of bees with a similar study of the Neotropical species. Although a considerable amount of material has been accumulated and some progress made in the study of the characters of the Neotropical species, a number of factors have made it seem inadvisable until now to publish any of the results.

The problem of determination of species is a very difficult one in this group of insects. A large number of species inhabit the region, and many of them look much alike superficially. Many of the descriptions stress these more superficial features and fail to mention the more reliable structural characters that are essential to their recognition. As a consequence, the positive identification of a large proportion of the species by the existing keys and descriptions is impossible. The types are widely scattered over the world, with important collections located in London, Berlin and Paris, in addition to those in North and South America. Until these type collections have been studied, particularly those including the types of the earlier described species, the majority of which are in Europe, the difficulties of specific determination will remain.

Another inherent difficulty in the study of this group is the marked sexual dimorphism characteristic of most of the species. This has resulted in the application of separate names to the two sexes of a large proportion of the species; or where two sexes have been described under one name, they have been mismatched in many cases.

Most of the species included in the material at hand, many of which apparently are in need of description, have been arranged in a scheme of classification comparable to that of the Nearctic species. It is the purpose of this paper to present this classification, incomplete as it is, in the belief that the characteristics and relationships of many of the inadequately described species will be made more clear through the assistance of systematists in other parts of the world who have access to type collections.

<sup>1</sup>Research Contribution No. 17, published with the aid of the State College Research Fund, Department of Zoology and Entomology, North Carolina State College of Agriculture and Engineering of the University of North Carolina.

<sup>2</sup>A Revision of the Genus *Megachile* in the Nearctic Region, Parts I-VIII, Trans. Am. Ent. Soc., 59: 295-361 (1934); 61: 1-44, 155-205 (1935); 62: 117-166 (1936); 62: 323-382 (1936); 63: 45-53, 175-200, 381-426 (1937).

A number of subgeneric groups which include species inhabiting the Neotropical region have already been proposed. These include three Old World groups, *Eutricharaea* Thomson (p. 671), *Archimegachile* Alfken (p. 671) and *Gronoceras* Cockerell (p. 671); and four Nearctic groups, *Lilomegachile* Mitchell (p. 662), *Anihemois* Robertson (p. 662), *Xanthosarus* Robertson (p. 662), and *Xeromegachile* Mitchell (p. 662). Each of these groups is represented in the Neotropical region by only one or two or three species. Of those representing the Old World groups, it seems evident that they were introduced after the discovery of America and that they do not represent normal elements in the fauna, although some of them seem to be quite successful and well established in the islands of the West Indies. The Nearctic species evidently represent southward dispersals from the centers of origin in North America, which have been accompanied by a slight degree of speciation.

Several subgenera have been proposed for groups which have their centers of origin in South America, but which have a limited representation in North America. These were all proposed in the Revision of the Nearctic species and include *Leptorachis* (p. 663), *Pseudocentron* (p. 663), *Acentron*, *Melanosarus* (p. 663), *Cressoniella* and *Neomegachile* (p. 662) Mitchell. Here again natural dispersal seems to be the explanation of their presence in North America, and the process of speciation is quite evident, most of the North American species being quite distinct from any of the numerous Neotropical representatives that have been seen. *Argyropile* Mitchell (p. 663) shows some evidence of relationship to certain of these groups and is represented by species in both regions, but it is better represented in the United States than in Mexico, and no material from south of Mexico has so far been received.

Two other groups, *Sayapis* Titus and *Chleostomoides* Robertson (p. 664), are abundantly represented in both regions, and it remains to be seen in which of the two their respective centers of origin lie.

Somewhat over half of all of the Neotropical species of *Megachile* that have been examined can be placed with a reasonable degree of assurance in one or another of these previously proposed subgeneric groups. This leaves a considerable number, however, that do not belong in any recognized group of this rank, hence a number of additional subgenera are proposed here to include a portion of these species. It is not possible at the present time to bring this classification near enough to completion to include all of the known Neotropical species, even of those that have been studied. Both sexes are necessary to characterize these subgeneric groups, and because of the rather extreme sexual dimorphism, the appearance of one sex is of little value in determining the characteristics of the other. However, among the reasonably well known species in which both sexes are known, it is possible to recognize five additional groups. The genotype of each one of these new subgenera will be described in some detail, especially stressing the structural features, but largely omitting details regarding the punctuation and the color patterns of pubescence or integument. These latter characters are often useful in specific distinctions, but are not ordinarily of much significance in the distinctions between subgenera.

## KEY TO SUBGENERA OF NEOTROPICAL MEGACHILE

## FEMALES

1. Sixth sternum either with a bare apical lip projecting beyond or above a subapical fringe of short hairs, or with center of the disc bare (figs. 18-20) . . . 2
- Sixth sternum without a bare apical lip, and with the disc largely covered with scopal hairs, at least basally (fig. 17) . . . . . 7
2. Mandibles 5-dentate, with a long bevelled cutting edge between the second and third teeth (fig. 2) (p. 663) . . . . . **Melanosarus**  
Mandibles usually 4-dentate; cutting edges between second and third teeth very short or lacking . . . . . 3
3. Sixth sternum without a bare lip projecting beyond the fringe, the fringe being quite apical in position (fig. 19) . . . . . 4
- Sixth sternum with a bare rim or ridge extending beyond the subapical fringe, 5
4. Third mandibular tooth broadly truncate, the inner angle acute, a long bevelled cutting edge between these, but none between the second and third (fig. 1); clypeus usually quite flat (p. 663) . . . . . **Leptorachis**  
Third mandibular tooth obtusely angular, the inner angle or tooth truncate, inconspicuous cutting edges between the second, third and fourth teeth (fig. 6); clypeus usually with a flattened median elevation (p. 666),  
**Austromegachile**
5. Apical rim of sixth sternum reflexed upward; bevelled cutting edge between second and third teeth much shorter and narrower than between third and fourth (p. 663) . . . . . **Argyropile**  
Apical rim of sixth sternum not reflexed . . . . . 6
6. Mandibles with distinct cutting edges between second and third and between third and fourth teeth (fig. 4) (p. 663) . . . . . **Pseudocentrôn**  
Mandibles with only one cutting edge and that between the third and fourth teeth (fig. 3) (p. 663) . . . . . **Acentron**
7. Mandibles without bevelled cutting edges that occupy the intervals between distinct angulate teeth (figs. 12-15) . . . . . 8  
Mandibles with a definite bevelled cutting edge which may be more or less covered by the inner teeth . . . . . 13
8. Form broad; abdomen cordate or ovoid; sixth tergum more nearly horizontal in position . . . . . 9  
Form narrow and elongate; abdomen parallel-sided; sixth tergum more nearly vertical in position . . . . . 12
9. Very large and robust (20 mm.); clypeus with a median elevated ridge toward apical margin (p. 671) . . . . . **Gronoceras**  
Much smaller (12-14 mm.); clypeus not ridged . . . . . 10
10. Sixth tergum distinctly concave, without conspicuous erect pubescence except near base (p. 662) . . . . . **Anthemois** (part)  
Sixth tergum nearly or quite straight in profile, with abundant erect pubescence . . . . . 11
11. Larger (12 mm. or more); vertex and mesonotum with copious and rather long pubescence; wings usually yellowish, the nervures and stigma pale ferruginous (p. 664) . . . . . **Chrysosarus**  
Smaller (10 mm. or less); vertex and mesonotum with thin and short pubescence; wings more nearly hyaline, with fuscous or black stigma and nervures (p. 670) . . . . . **Dactylomegachile**
12. Basal grooves of second and third terga more densely tomentose than the discs of those segments; sixth tergum with a subapical groove (p. 664),  
**Chelostomoides**  
Basal grooves of second and third terga not conspicuously tomentose; sixth tergum not grooved (p. 671) . . . . . **Archimegachile**
13. Mandibles with a distinct bevelled cutting edge between the second and third teeth, but none between the third and fourth (fig. 11); sixth tergum usually more nearly vertical, with the apical rim to some degree upturned (p. 664) . . . . . **Sayapis**  
Mandibles with at least a small bevelled cutting edge between the third and fourth teeth; sixth tergum more nearly horizontal and straight . . . . . 14
14. Mandibles 5-dentate, a deep emargination, occupied by a cutting edge, between the third and fourth teeth, the inner angle bidentate (fig. 8) (p. 662) . . . . . **Xanthosarus**  
Mandibles 4-dentate, or at least not of the above type . . . . . 15

15. Mesosternum and second abdominal sternum with a dense covering of fine plumose hairs, sharply differentiated from the other scopal hairs (p. 667),  
*Ptilosarus*  
Scopa and pubescence of mesosternum ordinary.....16
16. Abdominal sterna with entire and conspicuous white apical fasciae beneath the scopa (p. 671).....*Eutricharaea*  
Abdominal sterna with the fasciae interrupted medially or absent.....17
17. Innermost mandibular tooth or angle acute, the mandible distinctly 4-dentate (fig. 10); pubescence rather long and erect.....18  
Innermost mandibular tooth truncate, or slightly incised, the mandible being thus obscurely 5-dentate; pubescence shorter.....20
18. Pubescence so long and dense as to obscure the surface, though not completely hiding it (p. 669).....*Dasymegachile*  
Pubescence shorter, not nearly hiding the surface.....19
19. Sixth tergum straight in profile; second tooth of mandible rounded; mandibles usually with no cutting edge between the second and third teeth (p. 662).....*Xeromegachile*  
Sixth tergum usually concave in profile; mandibles with a small bevelled cutting edge between the second and third teeth, the second tooth acute (p. 662).....*Litomegachile*
20. Third mandibular tooth very broad and low, forming a broadly obtuse angle (fig. 6); median portion of clypeus elevated and flattened, the apical margin of this part shallowly incurved (p. 666).....*Austromegachile*  
Third mandibular tooth shorter and more acute (figs. 5 and 7); clypeus more nearly flat or evenly convex from one side to the other.....21
21. Smaller (9 mm. or less); sixth tergum with pubescence largely appressed, having few if any erect hairs; abdomen more elongate conical (p. 662),  
*Neomegachile*  
Larger (12 mm. or more); sixth tergum with abundant erect pubescence visible in profile; abdomen broader, more nearly cordate (p. 662) *Cressoniella*

## MALES

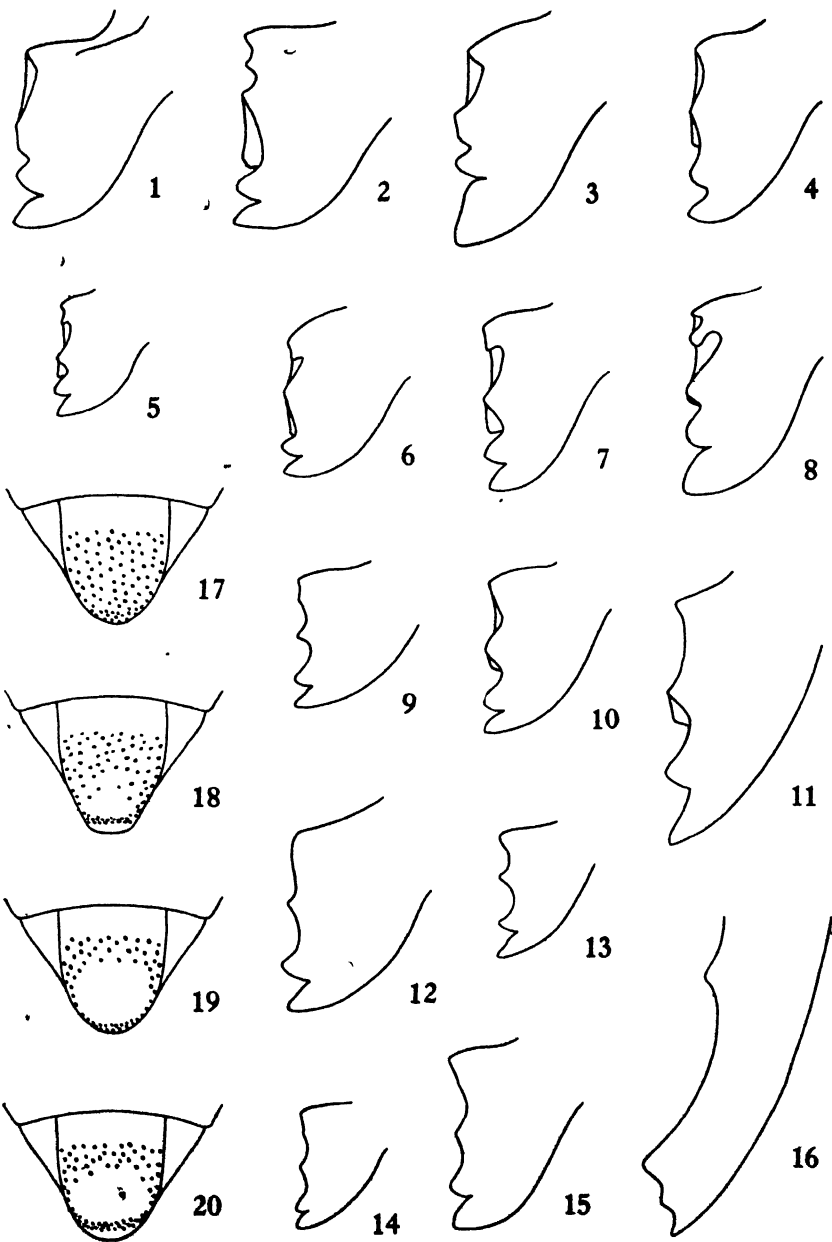
1. Abdomen terminated by a pair of very long slender and conspicuous spines, (p. 671).....*Gronoceras*  
Abdomen with short inconspicuous spines at the tip or none, or with a pair of triangular flattened spine-like carinae.....2
2. Abdomen with but three exposed sterna (p. 664).....*Chelostomoides*  
Abdomen with four sterna at least partially exposed.....3
3. Mandibles lacking an inferior projection or tooth.....4  
Mandibles with a definite inferior projection or tooth or angle.....11
4. Front coxal spines present.....5  
Front coxal spines absent.....7
5. Coxal spines very short and inconspicuous; basal segment of flagellum shorter than pedicel, the second nearly three times as long; small slender species with the sixth tergum above the carina nearly horizontal (p. 662),  
*Neomegachile*  
Coxal spines longer; basal segment of flagellum usually longer than pedicel, somewhat shorter than second segment; larger species, sixth tergum more nearly vertical.....6
6. Carina of sixth tergum with a deep rounded emargination; form more broad and short (p. 664).....*Chrysosarus*  
Carina of sixth tergum with a very shallow and barely evident emargination; elongate, the abdomen narrow and parallel-sided (p. 671),  
*Archimegachile*
7. First and second segments of flagellum subequal; carina of sixth tergum deeply emarginate; mandibles 3-dentate; pubescence abundant, long and erect (p. 669).....*Dasymegachile*  
First segment of flagellum shorter than second; carina of sixth tergum bispinose, or with the emargination very shallow or absent.....8
8. Carina of sixth tergum with a pair of acute spines.....9  
Carina of sixth tergum not bispinose, the lateral portions on each side of emargination more obtuse, if present.....10



9. Larger (12 mm. or more); pubescence erect and rather long; mandibles 4-dentate (p. 662)..... *Cressoniella*  
Smaller (about 7 mm.); pubescence very short, appressed; mandibles 3-dentate (p. 667)..... *Ptilosarus*
10. Abdomen broad and short, with very short sterna; sixth tergum entirely hidden by the fifth in dorsal view (p. 666)..... *Austromegachile*  
Abdomen narrow and elongate, the sterna more fully exposed; sixth tergum at least partially visible in dorsal view (p. 662)..... *Neomegachile*
11. Middle tibia lacking the usual apical spur..... 12  
Middle tibia with a distinct apical spur..... 15
12. Middle tibia with a spur-like apical projection; mandibles usually (but not always) with a median acute angle on the lower margin (p. 663),  
*Pseudocentron*  
Middle tibia without a spur-like apical projection, though often angulate or protuberant, but not as above..... 13
13. Middle metatarsi swollen at base, or with a pronounced ventral keel or tubercle (p. 662)..... *Xanthosarus* (part)  
Middle metatarsi neither swollen, carinate or tuberculate..... 14
14. Puncturation of thorax above extremely dense, with no shining spaces at all evident between punctures (p. 663)..... *Acentron*  
Punctures of thorax more definitely separated, shining spaces between the punctures evident at least on the mesonotum medially (p. 663), *Melanosarus*
15. Carina of sixth tergum conspicuous and entire, with no trace of a median emargination..... 16  
Carina of sixth tergum emarginate medially..... 17
16. Front tarsi slender and simple, black or fuscous; front coxae pubescent anteriorly, without red bristles, the spines short and slender; inferior tooth of mandible basal, slender and acute; apical segment of antenna not at all dilated, fully three times as long as broad (p. 663).... *Argyropile flavihirsuta*  
Front tarsi usually dilated, ferruginous or yellowish; front coxae usually bare anteriorly, with broad flat conspicuous spines and a patch of red bristles at their bases; inferior tooth of mandible usually robust; apical segment of antenna usually dilated, about twice as long as broad (p. 662)  
*Xeromegachile*
17. Mandibles 4-dentate..... 18  
Mandibles 3-dentate..... 19
18. Apical margin (not carina) of sixth tergum with both acute median teeth and conspicuous lateral teeth (p. 663)..... *Argyropile* (part)  
Apical margin of sixth tergum with barely discernible teeth or none, usually with minute lateral teeth (p. 663)..... *Leptorachis*
19. Mandibles with a robust inferior basal tooth..... 20  
Mandibles with a low median inferior angle in place of the usual tooth (p. 670)..... *Dactylomegachile*
20. Middle coxae with long slender spines (p. 662)..... *Xanthosarus comata*  
Middle coxae not spined..... 21
21. Front coxal spines reduced to inconspicuous tubercles..... *Anthemois*  
Front coxal spines well developed..... 22
22. Front tarsi usually broadly dilated, ferruginous or yellowish; form more elongate (p. 664)..... *Sayapis*  
Front tarsi usually simple and dark; form more shortened, the abdomen almost quadrate..... 23
23. Morphological apical margin (not carina) of sixth tergum without evident teeth (p. 671)..... *Eutricharaea*  
Apical margin of sixth tergum with distinct teeth (p. 662).... *Litomegachile*

#### EXPLANATION OF PLATE

Figs. 1-16, left mandible of female; 17-20, distribution of scopal hairs on sixth sternum of female. 1, *Leptorachis petulans*; 2, *Melanosarus xylocopoides*; 3, *Acentron albitarsis*; 4, *Pseudocentron pruina*; 5, *Neomegachile chichimeca*; 6, *Austromegachile montezuma*; 7, *Cressoniella zapoteca*; 8, *Xanthosarus latimarus*; 9, *Anthemois montivaga*; 10, *Dasymegachile saulcyi*; 11, *Sayapis pugnata*; 12, *Archimegachile lanata*; 13, *Chelostomoides otomita*; 14, *Dactylomegachile parsonsi*; 15, *Chrysosarus guaranítica*; 16, *Chelostomoides rugifrons*; 17, *Chrysosarus guaranítica*; 18, *Argyropile parallela*; 19, *Leptorachis petulans*; 20, *Pseudocentron pruina*.



Subgenus **Litomegachile** Mitchell

*Litomegachile* Mitchell, Trans. Am. Ent. Soc., 59: 301, 1934; *ibid.*, 61: 9, 1935.

Genotype: *Megachile brevis* Say. (Orthotype).

A specimen from Chalanga, Peru, labelled *M. buchwaldi* (anon.) belongs to *Litomegachile*, and a specimen of *M. texana* Cresson, a Nearctic species, has been recorded from Mexico.

Subgenus **Neomegachile** Mitchell

*Neomegachile* Mitchell, Trans. Am. Ent. Soc., 59: 302, 1934; *ibid.*, 61: 38, 1935.

Genotype: *Megachile chichimeca* Cresson. (Orthotype).

This group, in addition to the type species, includes *M. alta* Mitchell, *M. stomatura* Cockerell and *M. uniformis* Mitchell. All of these are primarily Neotropical, *chichimeca* being the only one so far recorded from the United States. *M. aegra* Mitchell evidently is the male of *chichimeca*.

Subgenus **Cressoniella** Mitchell

*Cressoniella* Mitchell, Trans. Am. Ent. Soc., 59: 302, 1934; *ibid.*, 61: 42, 1935.

Genotype: *Megachile zapoteca* Cresson. (Orthotype).

This entire group is Neotropical, although the range of *zapoteca* extends into the United States. The following species are included: *M. arcus* Mitchell, *M. boliviensis* Friese, *M. redondensis* Mitchell, *M. euceliae* Cockerell and *M. grandibarbis* Perez. This is probably a very incomplete list.

Subgenus **Anthemois** Robertson

*Megachile* (subgenus) Friese, Die Bienen Europa's, Th. 5, p. 35, 1899.

*Anthemois* Robertson, Trans. Am. Ent. Soc., 29: 168, 1903. Mitchell, Trans. Am. Ent. Soc., 59: 300, 1934; *ibid.*, 61: 155, 1935.

*Cyphopyga* Robertson, Trans. Am. Ent. Soc., 29: 169, 1903.

*Megachile* (s. str.) Robertson, Ent. News, 35: 374, 1924.

Genotype: *Megachile centuncularis* Linnaeus (= *infragilis* Cresson). (Orthotype).

*Anthemois* is represented in Mexico by *montivaga* Cresson which has been collected at Guadalajara. How much farther south it extends is not known.

Subgenus **Xanthosarus** Robertson

*Xanthosarus* Robertson, Trans. Am. Ent. Soc., 29: 172, 1903. Mitchell, Trans. Am. Ent. Soc., 59: 300, 1934; *ibid.*, 62: 120, 1936.

Genotype: *Megachile latimanus* Say. (Orthotype).

Two species of *Xanthosarus* are included in the Mexican fauna, *comata* Cresson and *cochisiana* Mitchell.

Subgenus **Xeromegachile** Mitchell

*Xeromegachile* Mitchell, Trans. Am. Ent. Soc., 59: 302, 1934; *ibid.*, 62: 325, 1937.

Genotype: *Megachile integra* Cresson. (Orthotype).

Two species belonging in this subgenus have been recorded from Mexico, *instita* Mitchell, described from the United States, and *boharti* Mitchell, described from Mexico and not known to occur north of the

Mexican border. Over forty species have been described from the United States and Canada.

Subgenus **Argyropile** Mitchell

*Argyropile* Mitchell, Trans. Am. Ent. Soc., 59: 302, 1934; *ibid.*, 63: 46, 1937.

Genotype: *Megachile parallela* Smith. (Orthotype).

Both *M. parallela* Smith and *M. townsendiana* Cockerell, which are chiefly Nearctic, are known to occur in Mexico, and in addition, *M. flavihirsuta* Mitchell was described from Mexico.

Subgenus **Acentron** Mitchell

*Acentron* Mitchell, Trans. Am. Ent. Soc., 59: 303, 1934; *ibid.*, 63: 74, 1937.

Genotype: *Megachile albitarsis* Cresson. (Orthotype).

Other species included in this subgenus are as follows: *M. bernardina* Schrottky, *M. candida* Smith, *M. candidella* Mitchell, *M. civilis* Mitchell, *M. lentifera* Vachal (= *limae* Schrottky, = *morosa* Mitchell) and *M. villaricensis* Mitchell.

Subgenus **Melanosarus** Mitchell

*Melanosarus* Mitchell, Trans. Am. Ent. Soc., 59: 303, 1934; *ibid.*, 63: 78, 1937.

Genotype: *Megachile xylocopoides* Smith. (Orthotype).

There are four known species of *Melanosarus* in the Neotropical region, as follows: *M. brancoensis* Mitchell, *M. maura* Smith, *M. proserpina* Schrottky (= *vernoniae* Schrottky, = *fumicosta* Strand) and *M. sedula* Smith.

Subgenus **Leptorachis** Mitchell

*Leptorachis* Mitchell, Trans. Am. Ent. Soc., 59: 301, 1934; *ibid.*, 63: 58, 1937.

Genotype: *Megachile petulans* Cresson. (Orthotype).

This is one of the most extensive Neotropical groups, and includes the following species: *M. chrysophila*, *paraxanthura*, and *portalis* Cockerell; *M. curta* Cresson; *M. schmidti* Friese; *M. squalens* Haliday (= *apicipennis* Schrottky); *M. aetheria*, *ampla*, *angularis*, *colombiana*, *continua*, *emendata*, *immanis*, *inconstans*, *indigopherae*, *intergradus*, *lorenziensis*, *numerus*, and *parata* Mitchell; *M. anisitsi* (= *hilarimorpha* Strand), *aureiventris*, *capra*, *friesei* (= *helicitarsis* Schrottky), *paranensis* (= *beniensis* Cockerell), and *paulistana* (= *subita* Mitchell) Schrottky.

Subgenus **Pseudocentron** Mitchell

*Pseudocentron* Mitchell, Trans. Am. Ent. Soc., 59: 303, 1934; *ibid.*, 63: 63, 1937.

Genotype: *Megachile pruina* Smith. (Orthotype).

This is the most extensive group of Neotropical species so far recognized, thirty or more names having been proposed for species which evidently belong in it. The list of species, which is evidently an incomplete one, follows: *M. barbadensis*, *pyrrhogastra*, *pyrrhotricha*, and *vanduzeei* Cockerell; *M. azteca* Cresson (= *rhodopus* Cockerell); *M. bidentata* Fabricius (?); *M. argentina* and *burmeisteri* Friese; *M. binolata* and *poeyi* Guerin; *M. gomphrenae* Holmberg; *M. hoffmannseggiae* Joergensen; *M. aurata*, *aurea*, *banksi* (= *abnegata* Cockerell), *benigna*, *cordovensis* (nec. Schrottky), *electrum*, *imperator*, *inscila*, *perila*, *prietana*,

*santaramensis*, *sterilis*, *trepida*, and *velhoensis* Mitchell; *M. anthidioides* Radoszkowski; *M. beroni*, *botucatuna* (= *arabilis* Mitchell), *jundiana* (= *chapadiana* Mitchell), and *pocograndensis* Schrottky; *M. curvipes* (= *fossoris* Smith, = *leucocentra* Schrottky), *deceptrix*, *elongata*, and *pulchra* Smith; *M. luctifera* and *pollinosa* Spinola; *M. asuncicola* Strand; *M. furcata* (= *aricensis* Friese) and *vincta* Vachal.

**Megachile (Pseudocentron) cordialis** new name

*Megachile cordovensis* Mitchell (nec. Schrottky), Trans. Am. Ent. Soc., 56: 189, 1930.

**Subgenus Sayapis** Titus

*Gnathocera* Provancher (nec. Kirby), Nat. Can., 13: 232, 1882. Provancher, Fauna Ent. Can. Hym., p. 716, 1883.

*Megachile* Provancher, Add. Fauna Ent. Can. Hym., p. 323, 1888. Dalla Torre, Cat. Hym. X, p. 417, 1896.

*Ceratiis* Robertson (nec. Kroy), Trans. Am. Ent. Soc., 29: 172, 1903.

*Sayapis* Titus, Proc. Ent. Soc. Wash., 7: 154, 1905. Mitchell, Trans. Am. Ent. Soc., 63: 175, 1937.

Genotype: *Megachile pugnata* Say. (Orthotype).

This group is well represented in both the Nearctic and the Neotropical regions. The Neotropical species include the following: *M. assumptionis* Schrottky, *M. coelioxiformis* Schrottky, *M. coelioxoides* Cresson, *M. cruziana* Mitchell, *M. dentipes* Vachal, *M. howardi* Cockerell, *M. inimica* Cresson, *M. mendozana* Cockerell, *M. pollicaris* Say, *M. ypiranguensis* Schrottky and *M. zapilana* Cresson.

**Subgenus Chelostomoides** Robertson

*Chelostomoides* Robertson, Can. Ent., 33: 231, 1901. Robertson, Trans. Am. Ent. Soc., 29: 167, 1903. Mitchell, Trans. Am. Ent. Soc., 63: 381, 1937.

*Oligotropus* Robertson, Trans. Am. Ent. Soc., 29: 167, 1903. Cockerell, Entomologist, 41: 292, 1908.

*Gnathodon* Robertson (nec. Oken), Trans. Am. Ent. Soc., 29: 167, 1903.

*Sarogaster* Robertson, Ent. News, 29: 92, 1918.

Genotype: *Megachile rugifrons* Dalla Torre. (Haplotype).

In addition to eighteen species known to occur in North America, the following are apparently limited to the Neotropical region: *M. abacula* Cresson, *M. cartagenensis* Mitchell, *M. gualanensis* Cockerell, *M. haematoxylonae* Mitchell, *M. ignacensis* Mitchell, *M. olomita* Cresson and *M. peruviana* Smith.

**Subgenus Chrysosarus**, new

Genotype: *Megachile guaranitica* Schrottky.

Wings in both sexes yellowish, with pale yellowish-ferruginous nervures.

*Male*.—Head about as broad as thorax, broader than long; eyes very slightly convergent below; clypeus densely pubescent, apical margin straight except for some small median crenulations; mandibles 3-dentate, the lower margin straight; basal segment of flagellum subequal to pedicel, considerably shorter than the second segment, and the following segments about twice as long as broad, the apical one not dilated; cheeks subequal to eyes in width in lateral view; vertex nearly flat, hind margin very slightly incurved, the

lateral ocelli about as near to the eyes as to the edge of the vertex; front coxae with short but distinct spines, quite densely pubescent anteriorly and thus without specialized setae; front tarsi somewhat dilated and flattened, but not at all excavated anteriorly, the metatarsi much shorter and narrower than their tibiae, the anterior apex somewhat produced; second segment of metatarsus about as broad as the metatarsus and about two-thirds as long, the following segments successively shorter and narrower, segments 1-4 with a dense posterior fringe; middle and hind metatarsi quite short and narrow, prominently fringed; middle tibia with the usual apical spur; claws deeply cleft; abdomen parallel-sided, carina of sixth tergum prominent and rather narrow, with a deep semicircular median emargination, the resulting two teeth acute; median carinate teeth of the apical margin of the sixth tergum very low, much nearer the minute and acute lateral teeth than to each other; four sternal plates exposed; fifth presternite extensive, almost linear in the narrow median area, but the large lateral areas occupying most of the plate, the medasternite broad and very short except in the center, the setae simple, rather short and sparse, but a dense tuft occupies the basal middle, the poststernal strip very broadly incurved, the medasternal setae extending onto its lateral portions; lateral portions of sixth presternite rather elongate, not clearly differentiated from the median part of the plate, with short hair-like setae along apical margin, the medasternal areas obscure, apparently represented by a slender bow-shaped sclerotized ridge, with no setae visible, the poststernal lobe broad and short, with a small median apical angle, the lateral angle produced into ear-like lobes; eighth sternum slightly expanded along apical margin; stipites of genital armature quite slender, the apex only slightly recurved and dilated, with a few very short apical setae, a dorsal groove forming a triangular lobe just above the base, sagittae quite straight, slightly exceeding the stipites in length, volsellae robust, acutely triangular apically.

*Female*.—Head subequal to thorax in width, broader than long, eyes slightly convergent below; clypeus slightly convex, the apical margin nearly straight, more or less denticulate; mandibles obscurely 5-dentate, having closely approximated apical and subapical teeth, an acute median tooth, and an obscure one between this and the inner angle, without any bevelled cutting edges, first segment of labial palpus longer than the second, the ratio about 4 : 3; cheeks slightly narrower than eyes in lateral view; vertex flat; lateral ocelli subequally distant from eyes and edge of vertex, distance between them slightly greater; front metatarsi short and rather slender, middle metatarsi much shorter and slightly narrower than their tibiae, hind metatarsi subequal in breadth to their tibiae, but much shorter; claws with small but sharp basal teeth; tip of front wings about attaining the tip of the abdomen; abdomen cordate, the apical tergum straight in profile, the apical sternum without a bare apical lip, well covered over basal half with scopal hairs, the more apical portion more thinly covered; pubescence dense and moderately long and erect on thorax, short and more or less appressed on abdomen dorsally, rather long, thin and erect over most of head, a dense semi-

circular tuft partially encircling the anterior ocellus and hiding the lateral ocelli in anterior view, and the posterior margin of the vertex with a dense erect fringe.

In addition to the type species, *guaranitica* Schrottky, the following belong in this group: *M. atricomma* Vachal, *M. ivonensis* Cockerell, *M. collaris* Friese, and *M. contemptus*, *tapytensis*, *congruens* (nec Friese), *aequalis*, *bella*, *turpis*, and *diversa* Mitchell. Moure suspects (in correspondence) that *bella* represents the true male of *guaranitica*. Apparently there is some variability in the color of pubescence in *guaranitica*, which has resulted in some confusion, but it is the only species in this group in which the sexes have been correlated, hence it is made the genotype.

**Megachile (Chrysosarus) congruata** new name

*Megachile congruens* Mitchell (nec. Friese), Trans. Am. Ent. Soc., 56: 248, 1930.

The name *congruens* is preoccupied, having been proposed by Friese (1903) for an Ethiopian species.

Subgenus **Austromegachile**, new

Genotype: *Megachile montezuma* Cresson.

*Male*.—Head as broad as thorax, broader than long; eyes convergent below; apical margin of clypeus with a small and shallow median emargination; mandibles 3-dentate, the lower margin straight; basal segment of flagellum subequal to pedicel, the second segment more than twice as long, it and the following segments more than twice as long as broad, the apical segment not dilated; cheeks subequal to eyes in width in lateral view; the vertex nearly flat, hind margin incurved, the lateral ocelli slightly nearer its edge than to the eyes; front coxae densely pubescent, with neither spines nor specialized setae; front femora very slender, but the tibiae robust and broadly dilated, being hardly twice as long as broad, the inner surface broad and flat, bare and highly polished; front tarsi in contrast exceptionally short and slender; middle legs slender, the metatarsi flattened, but narrower and much shorter than their tibiae; hind metatarsi shorter and narrower than their tibiae, but quite broad and flat, and equalling the following segments combined in length; middle tibiae with the usual apical spur; tarsal claws deeply cleft; abdomen quite short, the apex of the front wings (and rear also) extending considerably beyond its tip; carina of sixth tergum very low and inconspicuous, with a small median emargination, the apical margin of the plate entirely lacking the usual median and lateral teeth; four sternal plates exposed; fifth presternite linear medially, broad laterally, the medasternite about four times as broad as long, the apical margin broadly incurved, the surface hidden by two dense brushes of fine simple and rather long setae which are slightly separated along the mid line; the poststernal strip inevident; lateral portions of sixth presternite subtriangular in outline, the medasternal areas small, almost linear, distinctly separated medially, with but a very small patch of setae at the inner end of each, these setae fine straight and simple and directed toward the base of the plate, the poststernal

lobe very short, broadly rounded on each side, without lateral angles; eighth sternum evenly rounded apically; stipites of genital armature slender, strongly arched ventrally, the base of each with a deep dorsal groove, the basal margin of which is produced to form a robust rounded lobe, apex of stipites recurved, slightly dilated, almost bare; sagittae straight, about equalling the stipites in length; volsellae robust, triangular.

*Female*.—Head above barely equalling the thorax in width, only slightly wider than long; eyes convergent below; central area of clypeus somewhat elevated and flattened, the apical margin of this area incurved; mandibles 4-dentate, the apical and subapical teeth small and closely approximated, the third very broad and low, forming an obtuse angle, the fourth or inner tooth narrowly truncate, the emargination between the third and fourth deep and oblique, obscure bevelled cutting edges between the second, third and fourth teeth; first and second segments of labial palpi about equal; basal segment of flagellum subequal to pedicel, much shorter than the second segment, the middle segments almost twice as long as broad; cheeks narrower than eyes in lateral view; vertex flat, the lateral ocelli much nearer to its posterior margin than to the eyes; front metatarsi flattened, but distinctly shorter and narrower than their tibiae; middle and hind metatarsi shorter, the middle pair nearly as broad, the hind pair fully as broad, as their respective tibiae; claws with acute basal teeth; apex of front wings about attaining the tip of the abdomen; abdomen conical, the sixth tergum straight in profile, the apical sternum largely bare, the scopal hairs limited to the basal portion, but there is no bare apical lip; pubescence rather short, but dense and erect on thorax, longer on vertex, propodeum and base of abdomen, a quite dense fringe between the anterior and lateral ocelli, very short and suberect on abdomen dorsally.

The following species apparently allied to *montezuma* are included in *Austromegachile*: *M. fiebrigi* Schrottky, *M. trigonaspis* Schrottky (= *egressa* Mitchell, according to Moure), *M. lamnula* Vachal, *M. lenticula* Vachal, *M. semota* Cockerell, and *M. habilis*, *orbiculata*, *corona*, *recta*, *turbulenta*, *donata*, *certa*, *abnormis*, and *antiqua* Mitchell. The group apparently is limited to the Neotropical region.

#### Subgenus *Ptilosarus*, new

Genotype: *Megachile bertonii* Schrottky.

Small species, with shortened form, the pubescence very short and in part appressed.

*Male*.—Head broader than thorax, broader than long; eyes very slightly convergent below; clypeus bare except for a dense apical fringe, the margin beneath the fringe with three small median denticles; mandibles 3-dentate, lower margin straight and simple; basal segment of flagellum subequal to pedicel, the second segment somewhat longer, median segments nearly twice as long as wide, apical segment not dilated; cheeks slightly narrower than eyes in lateral view, the posterior margin sharply carinate; vertex slightly convex, hind margin very nearly straight; lateral ocelli subequally distant from eyes and edge of vertex, but much nearer to each other; front



coxae pubescent, with neither spines nor setae; all legs slender, the metatarsus of each leg no more than half as long or broad as the respective tibia; middle tibiae with the usual apical spur; tarsal claws cleft; coxae, trochanters, cheeks beneath, and mesosternum with fine dense plumose pubescence; abdomen very short, rather parallel-sided, the sixth tergum hidden beneath the fifth in dorsal view, its surface being vertical in position, the carina reduced to a pair of small acute triangular teeth, apical margin of the plate entirely lacking teeth; four sternal plates exposed; fifth sternum hidden but not appreciably modified, the medasternal area indicated by the presence of minute sparse and very short hairlike setae along the median apical half of the plate; presternal areas of sixth sternum longer than broad, with a small tuft of pubescence apically, the medasternal areas obscure, indicated by the presence of a few scattered minute hairs on median third of plate, the apical margin of this area being somewhat produced, the poststernal lobe equalling this area in width, quite extensive, the apical margin slightly outcurved, the lateral angles rather obtuse; eighth sternum with rounded tip; stipites of genital armature slender, flexed ventrally about midway to apex with quite long and conspicuous setae along the inner margin below the apex and a small apical tuft of shorter setae, the tips only slightly reflexed, a deep groove above the base, the basal margin of which forms a short acute tubercle; sagittae nearly straight, slightly exceeding the stipites in length; volsellae robust, triangular, acute.

*Female*.—Head broader than long, as broad as thorax; eyes slightly convergent below; clypeus broader than long, moderately and evenly convex, the apical margin broadly incurved medially, this portion with five or six minute crenulations; mandibles short, distinctly 4-dentate, spaces between the second, third and fourth teeth occupied by bevelled cutting edges, the apical tooth acute, the sub-apical tooth more rounded; first segment of labial palpus longer than second, ratio of about 5 : 3; cheeks about half as wide as the eyes in lateral view, the hind margin with a distinct sharp carina; vertex nearly flat, the lateral ocelli slightly nearer edge of vertex than to eyes, and slightly nearer each other than to edge of vertex; second segment of flagellum very slightly shorter than the first, the median segments broader than long; thorax slightly broader than long, fore tarsi slender, middle and hind metatarsi subequal in breadth to their tibiae, but slightly shorter; claws with sharp basal teeth; front wings projecting beyond the tip of the abdomen; abdomen short, cordate, the apical tergum straight in profile, the apical sternum without a bare apical lip, its surface largely covered with scopal hairs; pubescence dorsally very short, subappressed, slightly longer and erect around bases of antennae, lower angle of cheeks, pleura and propodeum, the coxae, trochanters, bases of the front and middle femora and the mesosternum densely covered with fine, rather short and densely plumose pubescence, and a pronounced V-shaped area of the same sort at the base of the abdomen, the remainder of the scopa normal.

The following species allied to *bertonii* are included in this group: *M. pilosa* Smith, *M. micrasoma* Cockerell, *M. aurantipennis* Cockerell, *M. microdoniura* Cockerell, *M. acerba* Mitchell, *M. cara* Mitchell, *M. bidentis* Cockerell and *M. pulchriventris* Cockerell.

Subgenus *Dasymegachile*, newGenotype: *Megachile saulcyi* Guerin.

Robust species, with long dense pubescence that usually obscures the surface of the integument.

*Male*.—Head about equal to thorax in breadth, broader than long; eyes slightly convergent below; clypeal margin straight and entire; mandibles 3-dentate, lower margin straight (not toothed or angulate); basal segment of flagellum much longer than pedicel, very slightly shorter than the second segment, middle segments about twice as long as wide, apical segment not at all dilated; cheeks broader than eyes in lateral view; vertex flat, hind margin incurved, the lateral ocelli somewhat nearer its edge than to eyes, distance from each other about equal to that from eyes; front coxal spines represented by obscure tubercles, the coxae pubescent and without specialized setae; front metatarsi short slender and simple; middle and hind metatarsi shorter and narrower than their tibiae; middle tibial spurs well developed; tarsal claws deeply cleft; carina of sixth tergum narrow, prominent, deeply emarginate, median teeth of apical margin of the tergum obscure, nearer to the lateral angles (which lack teeth) than to each other; four sternal plates exposed; fifth sternum not highly specialized, the presternite broad laterally, much shortened, almost linear medially, the medasternite about four or five times as broad as it is long, acute laterally, uniformly covered with fine unspecialized setae, the poststernal strip straight and inconspicuous; medasternal areas of sixth sternum well separated, densely covered with straight and simple setae, broadened at inner end, narrowed toward outer end of each area, poststernal lobe broad and very short, the lateral angles attenuated; eighth sternum of the usual *Megachilid* form; stipites of genital armature much constricted above base, the inferior margin of this constriction produced to form an acute carinate lobe, dilated and somewhat compressed above the constriction, the tips somewhat expanded and obliquely truncate, with a small tuft of short setae; sagittae nearly straight, fully attaining the tips of the stipites; volsellae triangularly pointed, small.

*Female*.—Head very slightly narrower than thorax, but broader than long, eyes only slightly convergent below; clypeus rather flat, the apical margin straight; mandibles 4-dentate, a rather long cutting edge between the two inner teeth; first and second segments of labial palpus about equal in length; cheeks slightly broader than eyes in lateral view; vertex rather flat, hind margin incurved, the lateral ocelli much nearer edge of vertex than to eyes, about as near each other as to eyes; basal segment of flagellum longer than the pedicel or the second segment, these subequal, the middle segments very slightly longer than broad; length and breadth of thorax subequal; front metatarsi robust, but considerably shorter and narrower than their tibiae; middle and hind metatarsi nearly as broad as their tibiae, but considerably shorter; claws with robust acute basal teeth; wings reaching about to apex of the abdomen; abdomen robust, but rather parallel-sided, the apical tergum slightly concave in lateral view, the apical sternum well covered with scopal hairs and without a

bare apical lip; pubescence long and copious throughout, resulting in an appearance like that of *Bombus*.

This group seems to be limited to the west slope of the Andes, and the only known species occur in Chile, Ecuador and Peru. Included are the following: *M. semirufa* Sichel, *M. garleppi* Friese, *M. piurensis* Cockerell and the genotype, *M. saulcyi* Guerin.

Subgenus *Dactylomegachile*, new

Genotype: *Megachile parsonsi* Schrottky.

*Male*.—Head slightly broader than thorax, broader than long; eyes very slightly convergent below; clypeus densely long pubescent, its apical margin with a shallow median emargination; mandibles 3-dentate, inferior margin with a very low submedian angle or tooth; basal segment of flagellum subequal to pedicel, the second segment longer, the middle segments twice as long as broad, the apical segment not dilated; cheeks very slightly narrower than eyes in lateral view; vertex slightly convex, hind margin almost straight; lateral ocelli subequally distant from eyes, edge of vertex and from each other; front coxae bare anteriorly, each with a small slender spine and a few inconspicuous short red bristles; front tarsi flattened, the metatarsus and the second segment subequal in length, the second slightly broader than the first and about equal to the tibiae in width, the third about half as long, and about as broad as long; middle and hind legs slender, their metatarsi not much more than half as long and broad as their respective tibiae; middle tibia with the usual apical spur; tarsal claws cleft; apex of wings reaching slightly beyond tip of abdomen; abdomen rather short; sixth tergum hidden by the fifth in dorsal view, its surface vertical, the carina broad and short, irregularly and coarsely denticulate, with a small and obscure median emargination hardly to be distinguished from the lateral crenulations, the apical margin of the plate with minute and obscure median teeth or angles which are much nearer the lateral angles than to each other; four sternal plates exposed; lateral portions of fifth presternite broad, each with a large patch of simple setae, the median portion relatively extensive, the medasternite very short, about four times wider than long, the median area and a rather narrow apical strip covered with fine long simple setae, poststernal strip slightly expanded toward each side, obscure medially; lateral portions of sixth presternite about as long as broad, with a quite large tuft of short pubescence apically, the medasternal areas hardly distinguishable, indicated only by a few scattered short and very obscure setae on each side of mid line, the apical margin of the median part of the plate with a fringe of very fine hairs, the poststernal lobe represented by a pair of triangular lobes on each side of center; eighth sternum slightly expanded apically; apical half of stipes of genital armature rather abruptly flexed ventrally, with a fringe of short hairs from here to the tip where there are a few longer hairs, grooved dorsally toward the base, the basal margin of the groove forming a quite distinct acute tubercle; sagittae straight, reaching about to the tip of the stipes; volsellae subtriangular, acute at tip.

*Female*.—Head about equalling the thorax in width, somewhat wider than long; eyes slightly convergent below; clypeus slightly

convex, median portion of the apical margin straight; mandibles obscurely 5-dentate, the two apical (first and second) teeth approximate, as also the two inner teeth, the third about median in position, the inner teeth low and obscure, and no bevelled cutting edges evident; first segment of labial palpus slightly longer than second, ratio about 5 : 4; basal segment of flagellum subequal to the pedicel, the second segment slightly shorter, middle segments about as broad as long; cheeks very slightly narrower than eyes in lateral view; vertex broadly convex, the hind margin slightly incurved, lateral ocelli about as near to each other as to the eyes, but somewhat nearer to the edge of the vertex; front metatarsi quite short and slender, middle and hind metatarsi shorter and slightly narrower than their respective tibiae; basal teeth of claws rather blunt except those of front legs which are acute; apex of front wings reaching fully to the tip of the abdomen; abdomen narrowly conical, the apical tergum very slightly concave in profile, the apical sternum uniformly covered with scopal hairs and lacking a bare apical lip; pubescence rather short but erect over most of head and thorax; more copious around bases of antennae, inner orbits, cheeks below, pleura, and propodeum, extremely short but mostly erect on abdomen dorsally, the apical tergum with numerous short erect hairs and much appressed tomentum.

Only two other species, *M. vagata* Vachal and *M. jenseni* Friese can be associated with the type species, *parsonsiae*, at present. The group appears to center in Argentina, and it seems probable that other species in that area will be found to belong here.

#### Subgenus *Archimegachile* Alfken.

*Archimegachile* Alfken, Konowia, 12: 55, 1933.

Genotype: *Megachile flavipes* Spinola. (Orthotype).

Included in this group are *M. lanata* Fabricius, *M. solitaria* Smith and *M. atriceps* Cresson, all recorded from the West Indies. Both *solitaria* and *atriceps* are probably synonymous with previously described Old World species. *M. lanata* is Oriental in origin.

#### Subgenus *Eutricharaea* Thomson

*Eutricharaea* Thomson, Hymen. Scandinav., 2: 228, 1872. Mitchell, Trans. Am. Ent. Soc., 63: 416, 1937.

*Paramegachile* Friese, Die Bienen Europa's, V, p. 34, 1899.

Genotype: *Megachile argentata* (Fabr.) Spinola. (Orthotype).

The three following species are recorded from the West Indies: *M. concinna* Smith, *M. derelictula* Cockerell and *M. multident* Fox. It seems probable that all three of these names will become synonyms of European or other Old World species.

#### Subgenus *Gronoceras* Cockerell

*Gronoceras* Cockerell, Ann. Mag. Nat. Hist. (7), 20: 65, 1907.

Genotype: *Gronoceras wellmani* Cockerell. (Orthotype).

*G. felina* Gerstaecker, an African species, has been collected in Jamaica.

#### *Megachile florensis* new name

*Megachile manaoensis* Mitchell (nec. Schrottky), Trans. Am. Ent. Soc., 56: 203, 1930.

# LIFE HISTORY OF SCIRTES ORBICULATUS FABIUS

(Coleoptera: Helodidae)<sup>1</sup>

FRED V. BEERBOWER,<sup>2</sup>

Kingwood, W. Va.

In July 1937, some unknown aquatic insect larvae were found in the vicinity of the University of Virginia's Mountain Lake Biological Station, in Giles County, Virginia. On July 31, 1938, additional larvae were found, and a culture was established. Throughout August of that year weekly collections were made and specimens were added to the culture. This work was continued through the summers of 1938, 1939, and 1941. Larvae were first collected in the field on July 22 in 1939, and on August 1 in 1941. During the four summers observations were made on the feeding habits, locomotion, respiration, and ecdyses of the larvae, on pupation, and on the activities of the adults.

These insects were identified from reared adults as *Scirtes orbiculatus* Fabius, of the family Helodidae (= Cyphonidae). The larvae of this family of beetles are only poorly known. According to Comstock (1933) there are 32 species in this family in our fauna.

## THE HABITAT

The larvae were found in an artificial pond on the J. K. Kessinger farm two miles southwest of Newport, Giles County, Virginia, and approximately ten miles south of the Biological Station. A few were located in two small lakes on the campus of Virginia Polytechnical Institute, Blacksburg. This campus is located some fifteen miles southeast of Kessinger's Pond, and separated from it by two mountain ranges. The region is in the southern Alleghenies, where the underlying limestone gives rise to numerous water-filled sink-holes. About ten such ponds in the vicinity were searched at various times, without discovery of the insect, either adults or larvae.

The limited distribution seems rather unique in view of the fact that the adults are active flyers and jumpers. Reitter (1909) mentions that the adults do not live where they emerge. In fact, sweeping of the vegetation on the pond banks by the writer yielded only eight adults. Lombardi (1928) records the fact that the Helodidae are not very common near Bologna, Italy, where she made collections. While she

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found them in great numbers in small, stagnant ponds, other waters nearby lacked them completely.

Kessinger's Pond is fed by strong cold springs. The settlement basin, approximately 90 feet in diameter, is formed by an earthen dam some three feet high. The overflow goes into a much larger and permanent pond that reaches a depth of about four and one-half feet. The surface is exposed to the sunlight and is shaded only on the east side. The banks are overgrown with sawgrass (*Cladium jamaicense* Crantz) and other low-growing hydrophytic plants. There is an extensive growth of the common pond lily (*Nymphaea advena* Ait.) on the western side. Drainage is through Spruce Run, the New River, and the Kanawha to the Ohio River. Life is abundant in and around the pond. The pond community seems well adjusted, after its ten years of existence.

The larvae were taken with a dip net in the shallow water near shore where dead vegetation had fallen into the water. Many were also found on floating sticks and boards that had been in the water long enough to acquire their own flora.

Careful observations were made in the native habitat as well as in the laboratory. The larvae were observed not far from shore crawling along the submerged stems or swimming with many pauses, ventral side up, just beneath the surface film. They move from one object to another several inches apart without rest. The swimming motion includes rapid leg movements and sidewise undulating motion of the body. At times the larvae literally walk beneath the film without undulation of the body. The larvae of *Scirtes tibialis* Guerin apparently have similar habits (Kraatz, 1918).

### DESCRIPTION

*Adult* (fig. 1).—Blatchley's description of the adult (1910, p. 694) is as follows:

"*Scirtes* Illig. 1807. . . Head deflexed; antennae [11-jointed] slender, half as long as body; prosternum short, not prolonged between the coxae, which are prominent and contiguous; hind coxae suddenly dilated on inner side into small plates; hind femora oval, very much enlarged, the tibia with one long and a shorter spur; tarsi with fourth joint bilobed, the first joint of the hind ones as long as the other joints combined."

"*Scirtes orbiculatus* Fab. . . . Broadly oval, sparsely pubescent. Black or piceous, shining; elytra with an oblong-oval reddish-yellow spot on middle of suture; thorax with sides usually broadly reddish-yellow; femora piceous, tibiae, tarsi and antennae paler. Head and thorax sparsely, elytra more densely and coarsely punctate. Length 2.5–3 mm."

*Larva* (figs. 2–14).—The mature larva (fig. 2) measures 5.5–6 mm. in length, exclusive of the antennae. The body is dark brown to black in color, with light splotches along the faint dorsal median line of the thorax. The body is campodeiform, i. e., elongate, sub-cylindrical, tapering caudally, and is broadest at the metathorax. The body segments are distinct; the body is prominently hirsute, and small tubercles support numerous spine-like setae of medium length. The lateral

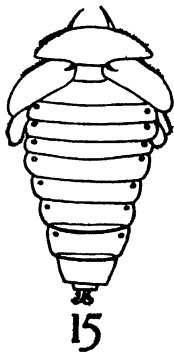
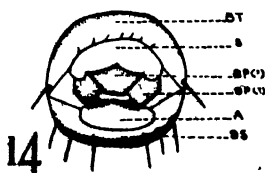
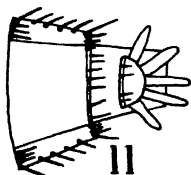
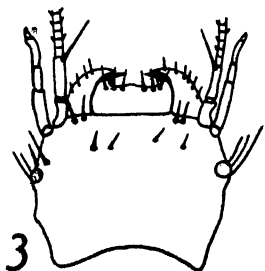
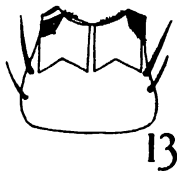
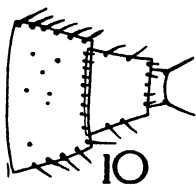
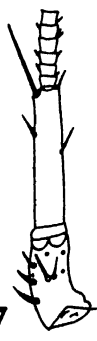
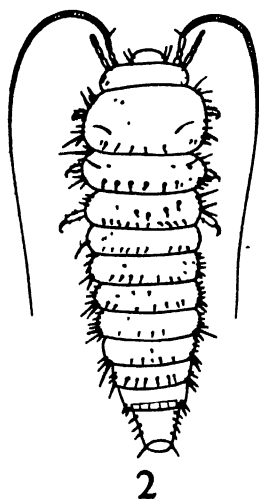
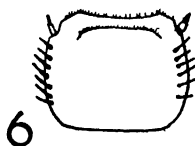
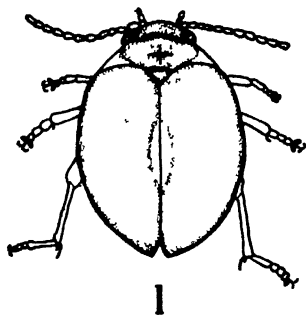
margins of the thorax, especially of the pro- and mesothorax, are flared slightly, shield-like, and bear numerous long setae which are nearly as long as the segment is broad. The prothorax is nearly twice as broad as the mesothorax, which is only a trifle broader than the metathorax.

The most conspicuous structures of the head capsule (fig. 3) are the extraordinarily long, setaceous antennae. They are attached anterior and sublateral to the eyes and above the base of the mandibles. The antennae average 2.8 mm. in length, which is half the body length; sometimes they are nearly as long as the body. Many specimens were collected with part of the antennae missing. Each antenna is composed of three large basal segments and numerous smaller segments, totaling perhaps 100 to 115. Kraatz (1918) speaks of 120 to 125 antennal segments. The small segments bear minute sensory papillae; these papillae are irregular in distribution and extend nearly the entire course of the antenna. Of the basal segments (fig. 7), the first is half the length of the third and is scarcely longer than broad; the third is long and slender; the second is small and inconspicuous. A single spine, three-fourths as long as the segment, is present on the median anterior edge of the third segment; another minute spine is located on the ventral, anterior edge; a third small spine is on the lateral and distal edge of the third segment.

The labrum (figs. 3, 5) arises from a very small clypeus; it is broader than long, and crescent-shaped on the anterior margin with a spine at each point; there are usually four spines on the lateral margins. The labium (fig. 6) is not cleft to form a ligula; the labial palpi are simple, two-segmented, small, and about as broad as long; the mentum is not clearly distinct from the submentum. The distal edge of the labium is covered with many small hairs. The maxillae (fig. 4) are fairly well developed and bear five-segmented palpi, the joints of which are hairy; the palpi project beyond the head. The laciniae bear on the inner margins numerous long, stout hairs. This brush-like arrangement makes the maxillae quite effective in the active feeding process. The mandibles (fig. 8) are fairly well sclerotized and are elongate-triangular, with pointed tips and with the inner surface curved or sickle-shaped; a molar region with six teeth is located near the base. The mandibles have tufts of hair-like spines along the inner surface, while the outer margins are rather evenly covered with fine hairs. The hypopharynx is

#### EXPLANATION OF PLATE

*Scirtes orbiculatus* Fabius. Figure 1. Adult, dorsal view ( $\times 7\frac{1}{2}$ ). 2. Mature larva, dorsal view ( $\times 10$ ). 3. Head of larva, dorsal view ( $\times 30$ ). 4. Left maxilla of larva, dorsal view ( $\times 35$ ). 5. Labrum of larva, dorsal view ( $\times 40$ ). 6. Labium of larva, ventral view ( $\times 40$ ). 7. Basal segments of right antenna of larva, dorsal view ( $\times 50$ ). 8. Mandibles of larva ( $\times 50$ ). 9. Hind leg of larva ( $\times 20$ ). 10. Dorsal view of caudal end of larva showing seventh and eighth tergites and doubtful sclerite (ninth pleurite?) ( $\times 20$ ). 11. Ventral view of caudal end of larva showing seventh, eighth, and ninth sternites, seventh pleurite, and retractile rectal gills ( $\times 20$ ). 12. Distal end of tracheal gill showing minute tracheoles (greatly magnified). 13. Last dorsal sclerite of larva, with two small sclerites of doubtful origin (ventral view) ( $\times 35$ ). 14. View of caudal end of larva, posterior view: S=opening of eighth spiracle; A=anal opening; 9S=ninth sternite; 8T=eighth tergite; 8P(?) and 9P(?)=possibly eighth and ninth pleurites. 15. Pupa, dorsal view ( $\times 7\frac{1}{2}$ ).





strongly developed and bears five outwardly curving hooks, arranged in a circle about a central orifice.

The legs show all of the usual parts. The three pairs are very similar, the posterior pair being slightly larger. Each tarsus bears a single curved claw which is used by the larva in clinging to objects. There are two minute spines on the claw, arising on opposite sides from the middle of the claw. The outer surface of the coxa is somewhat excavated, and each edge of the excavation bears a row of fine spines. The trochanter is present but difficult to distinguish. The legs are moderately covered with hairs, those on the tibia being more numerous and stouter. A row of four or more hair-like processes, longer than the tarsal claw, extends along the ventral side of each femur.

The abdomen consists of eight distinct segments, the first five having the same width as the metathorax, the last three tapering off sharply; the seventh segment is from one-half to three-fourths as wide as the metathorax, and the eighth is one-fourth as wide. The eighth segment has the appearance of being telescoped within the seventh. Nine sternites and seven pleurites are clearly seen on the ventral side. The ninth sternite is modified as an anal covering. The abdomen is quite hirsute, and has an irregular transverse row of spine-like setae on each segment. There are about five lateral spines on each segment, some of which are as long as the segment is broad.

*The Pupa* (fig. 15).—The pupa is elongate-rounded and 5 mm. in length. It is at first a creamy white, later turning to a dark gray. The head is deflexed and has prominent black eyes; the antennae are free from the body and folded beneath the head; no ocelli were observed on the pupa or larva. A fine pubescence covers the entire body, and it is especially dense on the head. The prothorax has two dark spines on the posterior dorsal margin and a second larger and longer pair on the anterior margin. Spiracles are located dorso-laterally on all abdominal segments. Several pupa were observed with the larval exuvia still clinging to the caudal end; one such specimen reached maturity with both larval and pupal exuviae still clinging to it. This specimen seemed normal except for slightly misshapen elytra. This condition has also been reported by Kraatz (1918). The pupae are capable of vigorous jerking movement, when disturbed.

## HABITS

*Feeding Habits of the Larvae*.—The larvae are vegetarians. No attempt to ingest animal life was observed; the larvae passed over minute snails, eggs, *Planaria*, Copepods and Protozoa. Kraatz (1918) states that the food of *Scirtes tibialis* is the duckweed, *Lemna minor*. *S. orbiculatus* larvae were never seen to eat plant leaves, but merely scraped more minute forms from the leaves and stems. The structure of the larval mouth parts is probably such that leaf-eating is not possible.

The larvae forage about on both upper and lower surfaces of submerged vegetation and other objects, sweeping with rapid motion of the maxillae as they move steadily forward. The maxillary palpi are quite active and appear to function as exploratory and sensory organs. The laciniae, or tooth-like parts of the maxillae, are quite broad; they are the most active scraping organs. The unusually long antennae con-

stantly move about with a lash-like motion, and probably aid the larva's course, since they are undoubtedly sensory. At times the animals were observed to clean their antennae of debris by pulling them under an elevated fore leg.

Larvae were most often taken on blades of dead saw-grass that had dropped into the water and were thoroughly water-soaked. On such objects were found a heavy growth of *Oedogonium*, diatoms, *Pharmidium lamnisonum*, desmids, and other algae (identifications by J. C. Strickland).

*Respiration of the Larvae.* The gills are five (sometimes four) small, white, unevenly rounded, finger-like retractile processes in the rectum. The rectal opening is on the ventral side of the ninth sternite; this sternite is much smaller than the preceding ones and serves as an anal covering, and can be lowered to allow the gills to be everted. By using transmitted light on living specimens, minute thread-like tracheoles can be seen in the gills. The tracheoles are bathed by a constant stream of blood, as shown by the movement of the leucocytes.

There have been much discussion and confusion in the literature regarding the respiration of helodid larvae. From his observations the writer believes the tracheal gills function as auxiliary respiratory organs. This is in accordance with the observations of Lombardi (1928), who states that they are used particularly when the larvae are in unfavorable conditions.

As the larva approaches the surface, the caudal end is brought into contact with, and pushed through the surface film. An opening appears just below the eighth tergite, and air is taken into the tracheal chamber. Immediately on submerging beneath the surface film, a bubble of air is apparently forced out of the tracheal chamber. This agrees with Lombardi's observations. The bubble remains until the larva is ready to come to the surface again for air, at which time the caudal opening is first closed, releasing the bubble, then reopened above the surface film. At no time were the gills everted while the larva was obtaining air at the surface, but they were nearly always protruded while the larva was beneath the surface. In a dorsal view the gills are just ventral to the air bubble, but they are not in contact with it, as can be seen from a lateral view.

By way of experimenting with the respiration, a larva was placed in a weak chloretone solution (anesthetic). No effects were noted for fifteen minutes; then respiration obviously became more labored. The caudal opening of the eighth tracheal spiracle was pushed through the surface film at ever-increasing intervals to take in air. The outline of most of the larger trachea could be seen pulsating more rapidly in apparent effort to secure oxygen. Meanwhile the gills remained everted. Gradually the larva succumbed to the anesthetic, but was later revived for a short time by placing it in fresh water.

#### DEVELOPMENT

A larva 2 mm. in length, which had probably just hatched, was collected on the morning of August 27; its size increased very rapidly, and by 2:00 P. M. it had become darkened and sclerotized. Fourteen days later (Sept. 11) it molted the first time, and the second molt

occurred fourteen days later (Sept. 24). No further molts were recorded for the following twenty-five days. On October 19 the larva crawled out of the rearing dish and disappeared. This one specimen was under constant observation for two months. Much of the time toward the end of this period the weather was very chilly, which probably affected the temperature in the rearing dish (which was located on an outside porch) more noticeably than in a natural pond.

The length of time between molts varied from seven to fifteen days (average, 10.1 days) in eight recorded molts (see Table I). The number of instars could not be definitely fixed, as most specimens had apparently undergone some molts when taken.

TABLE I  
DAYS BETWEEN LARVAL MOLTS

Days	Number of Larvae
7	2
8	2
11	2
14	1
15	1
Average = 10.1	Total = 8

The larvae were reared in dishes placed in a larger receptacle of water. The larvae were provided with water-soaked saw-grass blades and a small piece of wood taken from the native pond, which provided support as well as a food supply. When the larvae crawled out of the rearing dish they could be easily detected in the larger receptacle, and were picked out and placed in a small amount of damp sphagnum moss in tumblers. One or two small sticks were provided as a support for the mature insects, and the tumblers were covered with cheese cloth. The larvae crawled into the moss and excavated small cavities in which they pupated. In six cases where single specimens were placed in small receptacles, the larvae crawled out before they were ready to pupate; when in groups, none were observed to leave the rearing dish until they were ready to pupate. Larvae 8 and 9 (see table II) used moss and mud in the construction of pupal chambers. The mud was near the consistency of that on the bank of the native pond. In each case the pupal chambers were formed in the edge of the mud.

Larva 12 (Table II) was allowed to pupate in a small stender dish containing moist sand. After exploring a bit, the larva settled down to making a depression in the sand. This was a long laborious process; it started in the early afternoon and was not nearly completed by late at night. The larva lifted each grain of sand in its mandibles and placed it in place, an activity very much like that of a mud-dauber wasp. The following day nothing was to be seen except a completely capped-over pupal chamber. Four days later the adult beetle broke through the frail wall of the pupal chamber. It would thus appear that the place

of pupation is in the pond banks, above the water line. Lombardi (1928) describes *S. hemisphaericus* pupating in the pond bottom and the adult rising to the surface in an air bubble.

The long antennae of the larva (see fig. 2) are shed just before the time of crawling out for pupation. It is always the filamentous part, not including the three basal segments, that is shed. This probably facilitates pupation, as the antennae are out of the way when the larva is building the pupal chamber. The average pupal period for 22 specimens reaching maturity was four days (see Table II). Kraatz (1918) found the pupal period of *S. tibialis* (for nine specimens only) to be "about three days."

TABLE II  
PUPATION AND EMERGENCE OF *Scirtes orbiculatus* F.

Lot No.	NUMBER OF SPECIMENS		DATES		DURATION OF PUPAL STAGE (Days)	LENGTH OF ADULT LIFE (Days)
	Larvae Pupating	Adults Emerging	Pupation of Larva	Emergence of Adult		
1938						
1	3	2	Aug. 24....	Aug. 29....	5	16
2	5	4	Sept. 4....	Sept. 9....	5	11
1939						
3	2	1	July 29....	Aug. 2....	4	12
4	3	3	July 29....	Aug. 3....	5	10
5	3	2	Aug. 10....	Aug. 14....	4	Missing Aug. 22
6	4	3	Aug. 11....	Aug. 14....	3	Missing Aug. 16
7	2	2	Aug. 14....	Aug. 17....	3	Missing Aug. 22
8	1	1	Aug. 20....	Aug. 24....	4	*
9	2	2	Aug. 22....	Aug. 27....	5	*
1941						
10	1	1	Aug. 4....	Aug. 8....	4	5
11	1	0	Aug. 8....	.....	.....	.....
12	1	1	Aug. 8....	Aug. 13....	4	8
Total..	28	22	Average = 4.3			Aver. = 10.9

\*Adult specimens preserved before death.

The newly emerged adult is light colored except for the black eyes; sclerotization and coloration takes place in a few hours, when the adult beetle becomes active. Activity seems to increase at night. The adults are good flyers, and extremely active jumpers due to the much enlarged hind femora.

The adults remained in the tumblers until death. The average life of the imago was 10.9 days (Table II). No evidence of feeding, copulation, or egg-laying was observed.

The fact that the majority of emergences occurred during the month of August would probably indicate that the natural peak in nature occurs in this month. It may be noted that there was a decided decrease in the number of larvae taken from the pond during the middle and last of August. Blatchley (1910) records the adults of *S. orbiculatus*

in Stuben County, Indiana, June 17. The writer was unable to collect larvae before the last week in July during 1937, 1938, 1939, and 1941. Collections were made as late as August 16, but larvae were very scarce by that time.

Since eggs were not obtained, the ten-day incubation period recorded by Kraatz (1918) for *S. tibialis* may be used for purpose of estimate. From Table I the possible average time between molts is about 10.1 days; from one specimen observed to undergo four molts this would make approximately 40 days in the larval stage. Table II shows 4 days in the pupal stage and about 11 days in the imaginal stage. Summarizing, the lengths of the stages are: egg, 10 days; larva, 40; pupa, 4; imago 11; total 65 days.

### SUMMARY

Observations on the life history and habits of *Scirtes orbiculatus*, a beetle of the family Helodidae, were carried on over four summers, during which time 27 adults were reared from larvae. The larvae are aquatic, and feed on microscopic plant life. They occur on dead vegetation in the shallow water of ponds, and in this study were found largely in Kessinger's Pond, two miles southwest of Newport, Virginia. The mature larvae are campodeiform,  $5\frac{1}{2}$ -6 mm. in length, with antennae half as long as the body or longer. Respiration of the larvae is by means of a modified spiracle on the eighth segment, which is protruded above the surface film; the retractile rectal gills, which are true tracheal gills, serve as auxiliary respiratory organs. The duration of the life stages was found to be: egg, 10 days (estimated); larva, 40 days; pupa, 4 days; imago, 11 days; total, 65 days.

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CAUSES OF HEMLOCK MORTALITY IN NORTHERN MICHIGAN, by SAMUEL A. GRAHAM. University of Michigan, School of Forestry and Conservation, Bulletin No. 10. Pages 63, 19 figures, 6 x 9 inches, paper bound. Published by UNIVERSITY OF MICHIGAN PRESS, Ann Arbor, Michigan, 1943.

This bulletin discusses the ecological factors which have been responsible for the heavy hemlock mortality in northern Michigan in the last ten years, and recommends practices which will prevent much of this loss. This study is a good illustration of the fact that many of the problems of forest entomology are to be solved by proper methods of forest management.—D. J. B.

## ON THE ANATOMY OF *GRYLLOBLATTA* *CAMPODEIFORMIS* WALKER

### 4. EXOSKELETON AND MUSCULATURE OF THE ABDOMEN

E. M. WALKER,

Department of Zoology, University of Toronto

The terminal abdominal structures of both sexes of *Grylloblatta campodeiformis* have already been described by Walker (1919a, 1919b, 1922) in so far as the external parts are concerned; and the musculature of the female abdomen by Ford (1923). Crampton (1927, 1929) has also dealt with the terminalia as well as the general external features of the exoskeleton. No reference, however, has yet appeared in the literature to the internal skeletal parts of the male genitalia, nor has the abdominal exoskeleton as a whole been considered in detail.

At the time when Dr. Ford's work was done only one specimen of *Grylloblatta* was available for dissection. It is therefore not surprising that some of the muscles were overlooked by her and a few errors were made regarding the attachments of other muscles. The muscles of the first and tenth segments are not included in her description.

In the following account an attempt has been made, as in the preceding parts of this series, to follow, as closely as possible, the terminology employed by Snodgrass (1931, 1933, 1935).

#### EXOSKELETON

The abdomen of the adult female *Grylloblatta* is about one-half longer than the thorax, a little narrower than that region at the base, as wide or slightly wider at about the sixth segment, and narrows distally to the anal extremity. It has a slightly depressed subcylindrical form and the ten segments are all complete and well defined, the first segment showing less reduction than in any other orthopteroid insect that we have examined.

The first seven segments are similar in the two sexes, the cuticular covering of each consisting of a simple tergum and sternum and extensive pleural membranes. The tergum covers the entire dorsal surface of the segment; it is transversely slightly arched but is not bent downwards on the sides and does not form a free fold, such as is present in the meso- and metathorax. The front and hind margins are straight, the lateral margins convexly curved. Each segment appears to be bounded in front by an antecostal suture but cleared preparations show, in front of this suture, a short but distinct precostal rim, clearly demarked from the intersegmental membrane. This precosta is unpigmented and indistinguishable from the membrane in uncleared preparations. The antecostal ridge is very low and, in the first segment, very slightly indicated. Short hairs are fairly evenly distributed over each tergum. The tergum of the first segment, usually more or less reduced in Orthoptera, is as large as that of the second segment, differing only in the less distinct antecosta.

The sterna of the same segments are somewhat narrower than the terga, more thinly sclerotized, and are similarly clothed with short hairs. Each sternum has a narrow lateral membranous zone, as determined by the attachments of the lateral muscles. All except the first and the last two (9 and 10) are simple flattened sclerites, overlapping each other slightly from before backwards, except when fully extended. No distinct antecosta can be detected on any of them.

The sternal region of segment 1 (fig. 8) differs from the majority in being more extensively membranous, the only portion with a sclerotized cuticle being a rounded, median prominence, which lies between the hind coxae. Near its hind margin is the opening of an eversible sac, which is probably glandular. Figs. 1 and 9 show the sac in the retracted and everted position respectively.

The pleural membranes are very extensive and devoid of sclerotized areas, neither paratergites nor parasternites (Snodgrass, 1931) being present. This condition, as indicated by the insertions of some of the lateral muscles, is due to desclerotization of the primary tergum and sternum, which were separated by the pleural line, just below the spiracles (Snodgrass, *l. c.*). The membrane is clothed with hairs but they are shorter, finer, and more sparsely distributed than on the sclerites.

The spiracles (figs. 2, 3) are minute circular pores in the pleural membrane, without any surrounding sclerotization. The opening is partly covered by a thin cuticular membrane penetrated by a central aperture. The cuticular lining of the short tube which leads to the trachea is raised into numerous irregular, curled, hair-like processes, forming a loose network, which doubtless serves to prevent the entrance of foreign particles.

#### EXPLANATION OF PLATE I

*Grylloblatta campodeiformis* Walker. Figure 1. Left profile view of abdominal segments 1 and 2, showing eversible sac extended. 2. Spiracle from segment 1 of male. This is typical of the abdominal spiracles of both sexes. 3. Spiracle from segment 8 of male, showing the larger size as compared with typical spiracle shown in fig. 2. 4. Fourth and fifth segments of cercus, showing three different types of hairs. 5. Female ventral view of sternum of segment 8 and bases of first valvulae. 6. Female second and third valvulae in dorsal view. 7. Right half of ovipositor and basal sclerites viewed from within.

#### EXPLANATION OF ABBREVIATIONS USED IN THE PLATES

ac—accessory sclerite of right phal-  
mere.  
ap—apodeme.  
bv—basivalvula.  
ce—cercus.  
cp—copulatory process.  
cxl, cxr—left and right coxal plate.  
dv—dorsal blood vessel or heart.  
ep—epiproct.  
es—eversible sac.  
go—vas deferens.  
iap—inferior apodeme.

pa—paraproct.  
ph l, ph r—left and right phallomere.  
sap—superior apodeme.  
siv—superior intervalvula.  
sp—spiracle.  
spd—duct of spermatheca.  
st—sternum.  
tg—tergum.  
V1, V2, V3—first, second and third  
valvula.  
v. f.—valvifer.





## TERMINAL SEGMENTS OF THE FEMALE

Segments 8 and 9 in the female are modified by the development of a large ovipositor similar to that of the more primitive Saltatoria of the suborder Ensifera.

The tergum of segment 8 is similar to those of the more anterior segments but much smaller than that of segment 7. The sternum is remarkable in that it is not enlarged to form a specialized subgenital plate as in the Saltatoria. It is relatively wider than the other sterna, extending farther dorsad on each side, so that the pleural membrane is much narrower than on the segments in front. Posteriorly it is slightly emarginate where it forms the ventral margin of the large vaginal orifice and meets the bases of the first or ventral valvulae, which bound this passage laterally. The cuticular lining of the vagina extends forward as far as the anterior margin of the 8th segment, the lateral walls being continuous with the mesal walls of the first valvulae, while its ventral wall is adjacent to the sternum of segment 8. On the roof of the vagina, in the middle of segment 8, is a small, rounded button-like plate, through which opens the duct of the spermatheca. The last pair of spiracles opens in the pleural membrane of segment 8.

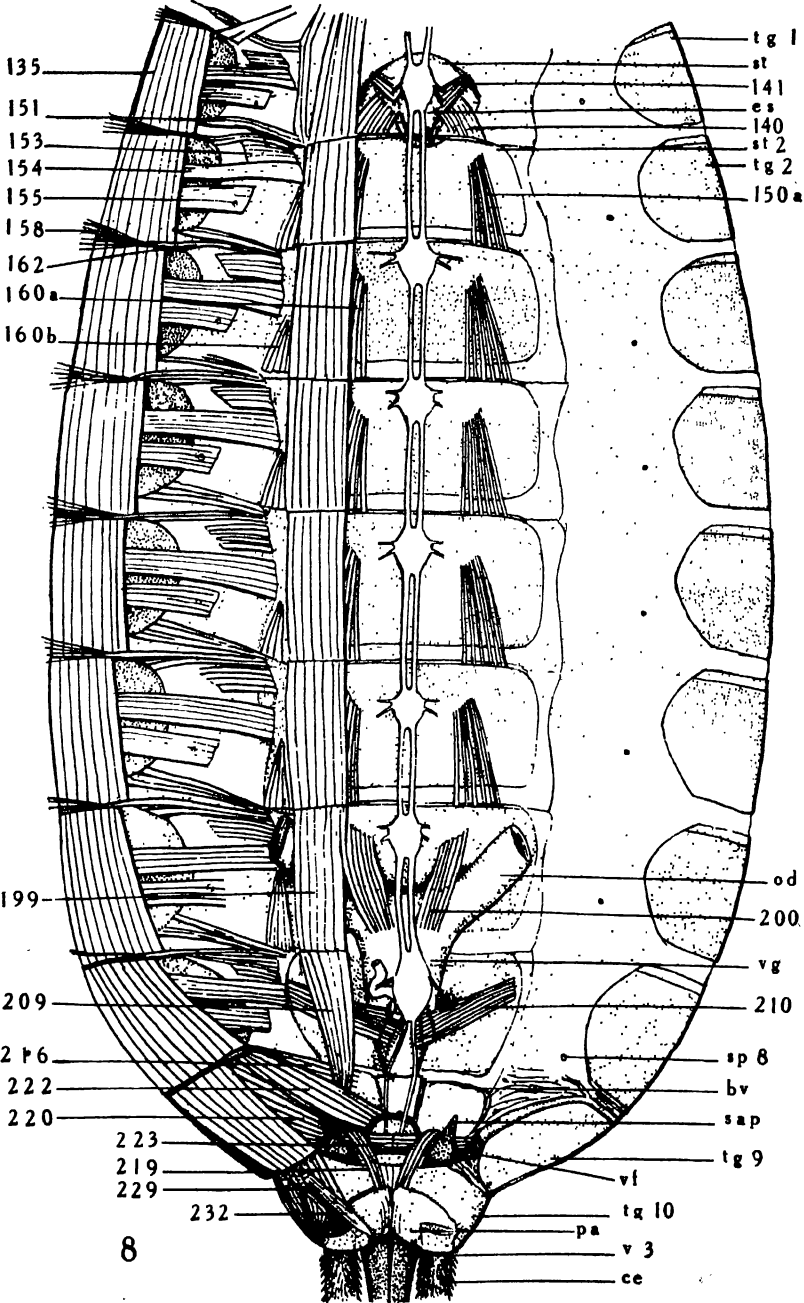
The tergum of segment 9 is dorsally narrower than that of 8 but extends farther ventrad on each side, reaching the bases of the first valvulae. The anterior margin has the usual connection with the tergum of segment 8 but extends latero-ventrad beyond it so as to be connected also with the latero-dorsal margin of the sternum of 8 and the basivalvulae. The antecosta is similar dorsally to those of the preceding segments but ventro-laterally, where it is connected by membrane with the sternum of segment 8, it is continuous with a strong *lateral apodeme* for the attachment of muscles of the ovipositor.

*The Ovipositor* (figs. 6, 7).—*Grylloblatta* possesses a large, exserted ovipositor much like that of the more primitive Ensifera. All three pairs of valvulae are well developed, the third pair being the longest, the first pair a little shorter, while the second pair, which is partly concealed by the third pair, is the shortest, but is by no means vestigial. The individual valvulae are all flattened and blade-like with acute apices lacking teeth, but the ovipositor as a whole is scarcely compressed and, although the first and second valvulae fit together by a loose tongue-and-groove engagement, the valvulae do not meet together in a single apex, as is usual in the Ensifera, the tips of the third valvulae projecting separately beyond the other pairs. A distinctly Orthopteran feature is the dorsal position of the third valvulae, which form an integral part of the ovipositor rather than a mere pair of sheaths for the other valvulae.

At the lower extremity of the lateral apodeme the tergum of segment 9 articulates with the *valvifer* (fig. 7), a small triangular sclerite, which articulates also with the base of the first (ventral) valvula and the

## EXPLANATION OF PLATE II

*Grylloblatta campodeiformis* Walker. Figure 8. Abdominal wall cut longitudinally near the mid-dorsal line, and spread out so as to show the musculature. The terga are not shown in their entire width. The muscles of the right side with the exception of the mesal group of the outer ventral series have been removed to show the exoskeletal features.



second (inner) valvula. This sclerite has recently been termed the *first valvifer* by Snodgrass (1933), who interprets it as a vestige of the coxal plate or limb-base of segment 8. Snodgrass' *second valvifer* is the broad basal part of the third (dorsal) valvulae as recognized here. This is acknowledged by all to represent the limb-bases of segment 9. Thus, according to this theory the so-called first and second valvifers are serially homologous structures. Snodgrass' concept is derived largely from conditions met with in the Homoptera in which there is a marked resemblance between the parts termed first and second valvifers, but we believe that this resemblance is a secondary one and that the parts so named are not serially homologous. In this belief we are supported by Ander (1939). The matter will be dealt with under the head of "Discussion."

The first valvulae each consist of two segments, a smaller basal segment or *basivalvula* and a long distal blade. The basivalvulae (fig. 5) articulate with the distal margin of the sternum of segment 8, which encircles them laterally. Dorsally they are contiguous with the valvifer and the ventral extremity of the tergum of segment 9. Their mesal walls are membranous and are continuous with the lateral walls of the vagina and the mesal walls of the blade.

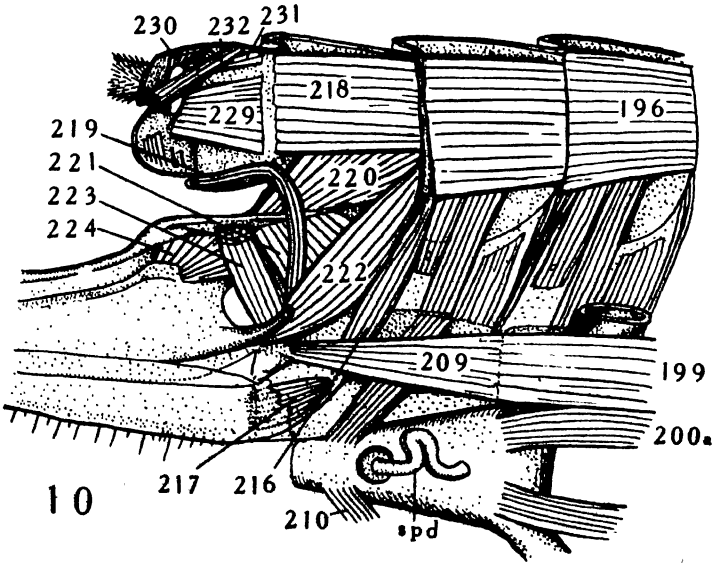
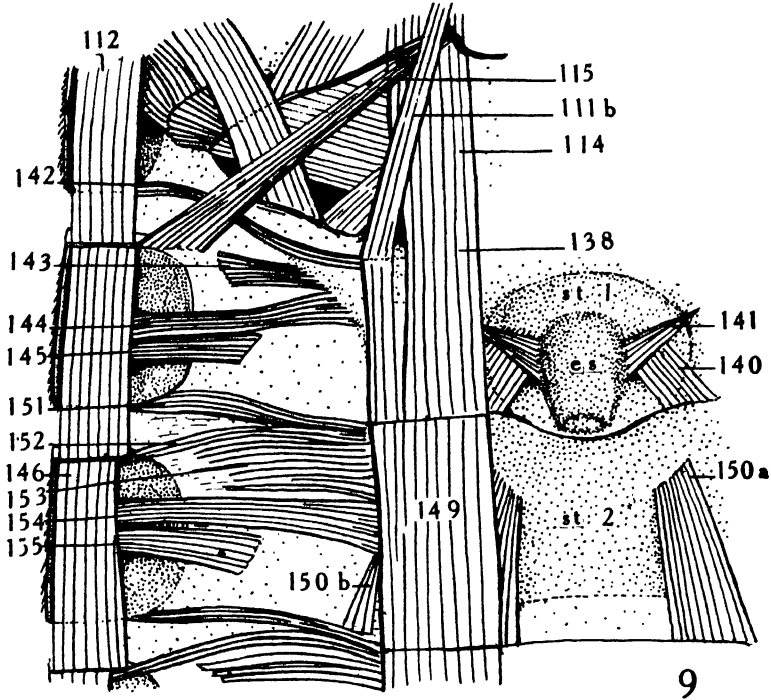
The *blade* of the first valvula is slightly compressed and upcurved. Its latero-basal angle articulates with the postero-ventral angle of the valvifer. Only its ventro-lateral walls are sclerotized, the dorsal and mesal walls being membranous. Along the dorsal edge of the lateral wall is a partly membranous groove, which engages the lower edge of the corresponding second valvulae. The sclerotized surface bears numerous stiff hairs.

The *second* or *inner valvulae* (figs. 6, 7) are exposed laterally but concealed when the ovipositor is viewed from above or below. They are considerably shorter than the first valvulae and are devoid of hairs. They are connected proximally by a fold of integument, the *inter-valvular membrane*, which is dorsally convex where it fits into the concavity formed by the expanded bases of the third valvulae. Across the dorsal wall of this membrane, at its highest level, is a sclerotized bridge which connects the bases of the blades. The median part of this bridge is thickened to form a pair of prominences for the attachment of muscle No. 224. The ventro-lateral margins of the second valvulae fit into the groove along the dorsal margins of the first valvulae.

The *third* or *dorsal valvulae* (figs. 6, 7) are the longest of the three pairs. Their basal parts are expanded and flaring, meeting one another dorsally at a point just above the bridge which connects the second valvulae. The dorso-lateral basal angle of each valvula is produced into a *superior apodeme* and the base of the apodeme is laterally slightly notched to articulate with the dorsal angle of the valvifer (fig. 7). Between the divergent superior apodemes the cuticle is semi-mem-

#### EXPLANATION OF PLATE III

*Grylloblatta campodeiformis* Walker. Figure 9. Muscles of abdominal segments 1 and 2, and muscular connections with metathorax. 10. Muscles of abdominal segments 7 to 10 of female, including ovipositor, cerci and anal valves, left side from within.



branous and unpigmented and the only indication of the superior intervalvula is a thin median septum, attached to the cuticle above, and separating the intervalvular muscles of the valvifer (No. 223).

The ventro-lateral basal angles of the third valvulae are also produced into a pair of *inferior apophyses* which are prolonged mesad into a pair of slender curved bars uniting with one another on the middle line. These united bars perhaps include the inferior intervalvula, which in the Ensifera forms a distinct sclerite.

Distally the third valvulae are somewhat depressed and taper to slender pointed apices. They are sclerotized dorsally and laterally and bear a few scattered hairs.

The tenth segment (figs. 10, 20-23), although small as compared with the other segments, is more prominent than in most Orthoptera, resembling that of the Phasmaria in this regard. Its tergum encircles the greater part of the segment, covering dorsal and lateral surfaces and is indistinctly demarcated from the sternum, which is only thinly sclerotized. The antecosta is present as in other segments.

The cerci are about as long as the last five segments in a state of average extension and are cylindrical tapering appendages, composed of eight distinct segments, the basal segment being the equivalent of two partly divided segments. The segments increase in length distad to the sixth or seventh, the eighth being slightly or considerably shorter than the seventh segment. The eighth or terminal segment is, however, always the most slender. The cerci are densely clothed with hairs (fig. 4), which are of several sizes: (a) the general covering of ordinary short body hairs, (b) a group of three or four long stout hairs around each segment about the middle, and (c) a circlet of about eight still longer and very slender hairs near the distal end of each segment except the last, each hair arising from a circular pit. These hairs are probably tactile in function.

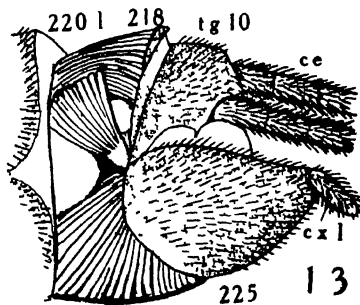
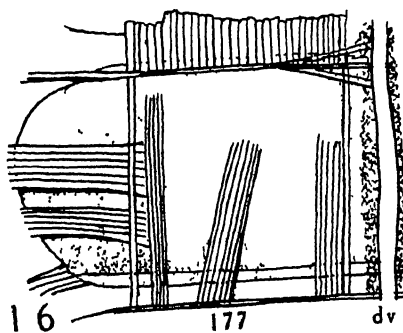
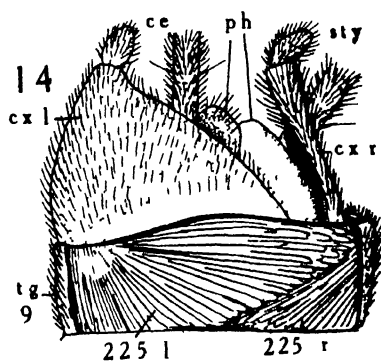
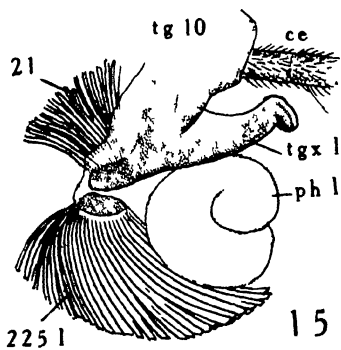
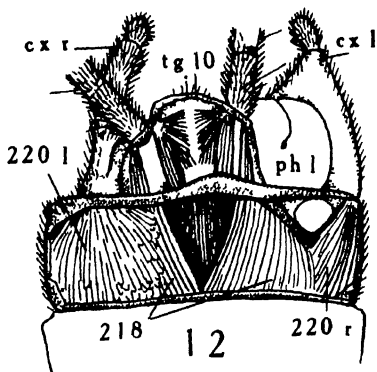
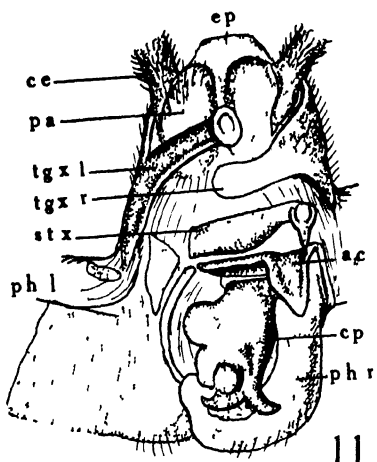
The epiproct (fig. 23) is a small, rounded, depressed flap, thinly sclerotized dorsally, with a few scattered hairs. The paraprocts (figs. 20, 23) are moderately prominent, rounded membranous lobes, with slightly sclerotized lateral walls.

#### TERMINAL SEGMENTS OF THE MALE

The abdomen of the adult male differs in general form from that of the female in that segments 8 and 9 are much larger, segment 8 being about as large as segment 7, while segment 9 is considerably enlarged, being specialized as a genital segment. Both segments 9 and 10 are, in fact, asymmetrically modified for copulation. Segment 8 shows no

#### EXPLANATION OF PLATE IV

*Grylloblasta campodeiformis* Walker. Figure 11. Copulatory structures of male, posterior view. 12. Dorsal musculature of segments 9 and 10 of male. 13. Segments 9 and 10 of male abdomen, with body wall of segment 9 removed to show muscles. 14. Coxal plates and outer phallic muscles of male, exposed by removal of ninth sternum. 15. Left lateral region of tenth tergum, showing left tergal arm, left phallomere and muscular connections. 16. Under surface of tergum of a typical segment (segment 5) with inner dorsal muscle removed (except bounding fibres), to expose outer dorsal muscles.



In Figure 12 *220 r* and *220 l* should be transposed.  
In Figure 15 muscles labelled *21* should be *218*.

noteworthy difference from segment 7. In both of these segments the pleural membrane is considerably narrower than in the preceding segments and the spiracles are larger. Segment 9 is somewhat flaring, the left side being slightly longer and more divergent than the right side. The anterior margin of the tergum bears a very strong antecosta. The posterior margin is convexly produced, the convexity being more prominent to the left of the median line. The tergum is practically fused with the sternum, there being merely an indistinct lateral suture in place of the pleural membrane.

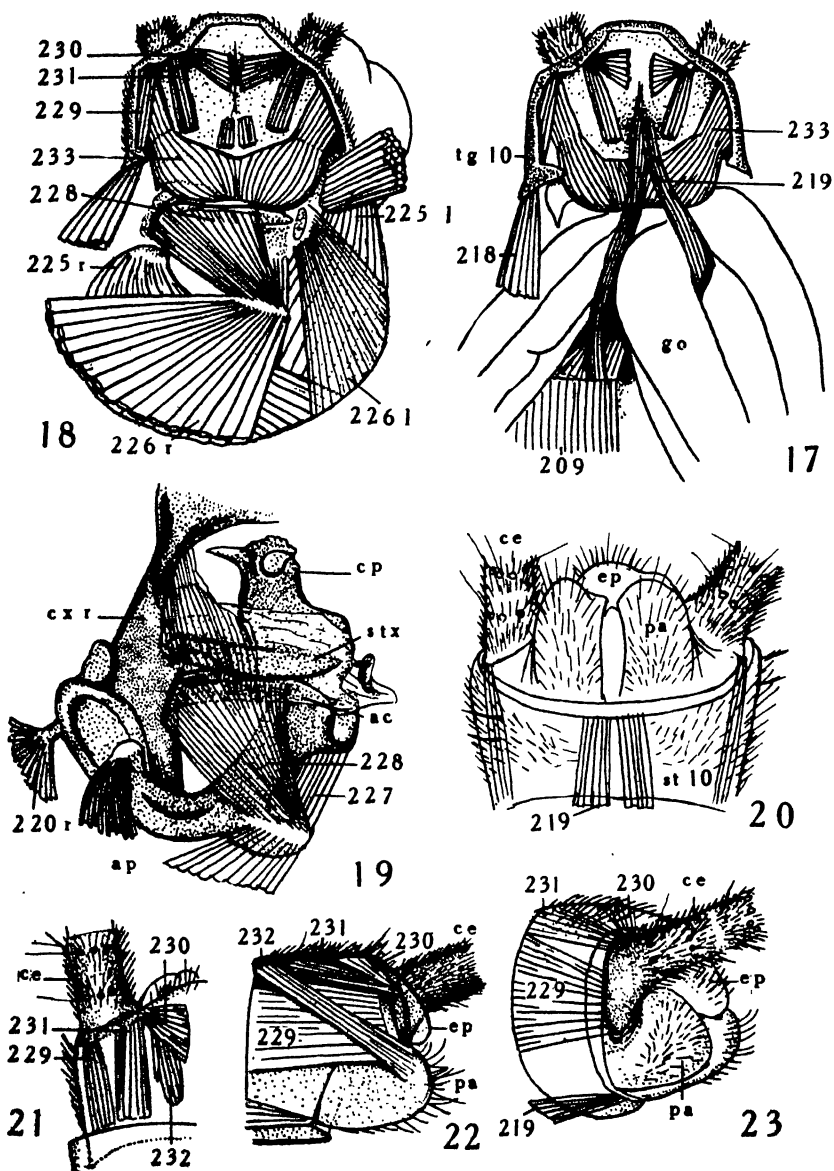
The sternum of segment 9 occupies the whole width of the segment and extends upwards on each side to meet the tergum. Close to the anterior margin, which is slightly irregular, there is a strong antecostal ridge. Articulated with the broadly convex posterior margin of the sternum are the two coxal plates or limb-bases, each of which is a flattened, triangular process, bearing at its apex a hairy stylus. Both coxal plates bear a thickened basal ridge for the insertion of the adductor muscles. The two coxal plates are separated at their bases by a distinct interval, which is well to the right of the middle line. The left coxal plate (figs. 12, 14) is three times as broad, at base, as the right coxal plate (figs. 12, 14) and is considerably broader than long.

It is a scoop-like structure, ventral and lateral in position and forms a sort of asymmetrical subgenital plate. The right coxal plate, on the other hand, is narrower than long and wholly lateral in position. Near the base of its dorsal margin is a short, thumb-like process, bent inwards. This coxal plate serves as a clasper in copulation.

The tenth tergum (figs. 11, 12) appears from above to be similar to that of the female, except that it is slightly asymmetrical in outline and the antecosta is greatly thickened. Viewed from other angles, however, it is seen to be considerably modified and strongly asymmetrical. The lateral lobes are produced into a pair of free arms (fig. 12), which nearly meet ventrally, just below, and in front of, the paraprocts. The left arm is long, heavily sclerotized, and terminates in a button-like disk. There is also a ventral extension of the basal rim of the segment on this side, to which powerful muscles are attached. The right arm is comparatively short and spatulate, and is distally unpigmented and semi-membranous. The basal rim of the tergum on this side is slightly prolonged but much less so than the corresponding left structure. The left arm probably serves as a brace in opposition to the right coxal plate, which functions as a clasper.

#### EXPLANATION OF PLATE V

*Grylloblatta campodeiformis* Walker. Figure 17. Dorsal dissection of terminal segments of male abdomen, showing the terminal bundles of the inner ventral muscles (219) among the parts of the reproductive organs. 18. Muscles of phallus and tenth segment, dorso-anterior dissection of male. 19. Copulatory process of male from within, showing the large apodeme and its special muscles. 20. Tenth segment and anal valves of female, ventral view. Terminations of inner ventral muscles and abductors of cerci showing through transparent body wall. 21. Muscles of cercus, female, dorsal view of left side. 22. Tenth abdominal segment of female, vertical section right of the median sagittal plane. 23. Tenth abdominal segment and anal valves of female, left postero-lateral view, showing muscles of cercus through transparent body wall.





The *phallus* is of primitive type in that it consists of two separate lobes or phallomeres, right and left (Snodgrass, 1937). The two lobes are divided by an irregular, oblique fissure, which is dorsally left of the middle line, ventrally a little to the right of the middle. Distally the right lobe is folded over the left lobe. The two lobes are extremely different in form and structure.

The *left phallomere* (figs. 11, 15) is a large, membranous, tubular sac, which forms a single coil when extended. Ordinarily in the living insect the sac is retracted. The only sclerotized areas of the left lobe are the following:

(a) A moderate-sized area on the ventral and posterior walls at the base and close to the median fissure. This area is continuous with the basal rim, adjacent to the sternum of seg. 9. A small patch of hairs is borne by the somewhat smaller, posterior part of this area.

(b) A small triangular area on the left side of the interlobar fissure, at its upper extremity. This is a thinly sclerotized plate, serving for the attachment of a muscle (No. 225).

(c) A small oval plate adjacent to the ventral extremity of the base of the left tergal arm, with which it forms a sort of articulation. It serves for the insertion of the powerful muscle No. 225.

We are still unable to suggest what the function of the sac-like structure may be. It is filled with a loose connective tissue and appears to have no communication with the ejaculatory duct.

The stout basal part of the right *phallomere* is moderately well sclerotized ventrally, posteriorly and laterally, but is membranous mesally, where it meets its fellow of the left side, and is partially so dorsally, where it is invaginated to form a sheath for the principal *copulatory process* (fig. 11). This is a complex and highly sclerotized structure, which is prolonged into the haemocoel in the form of a large basal apodeme for the attachment of muscles. Externally the main part of this structure projects from its sheath in the form of a stout, irregular process, terminating in two points, of which the larger is directed laterad. The basal apodeme (fig. 19), which is the inward extension of this copulatory process is a long stout bar, which swings dextrad, terminating in two blunt hooks, a long lateral and a shorter mesal one.

The *accessory sclerite* of the right phallomere (figs. 11, 19) is an asymmetrical plate, lying antero-dorsally (morphologically posterior) to the principal copulatory process. Dextrally it projects as a free process, which turns ventrad, while mesally it forms a somewhat curved transverse bar embedded in the sheath of the copulatory process and serves for the attachment of muscles. The right extremity of this bar, as viewed from within, is enlarged, forming the base of the free external process and the principal point for the attachment of muscles. This accessory sclerite is comparable in position to the epiphallus (pseudosternite) of the Saltatorian family Acrididae and both have muscular connections with the sternum of segment 9, but it is not claimed that there is any true homology between these structures.

The ejaculatory duct, which is a very short passage between the two phallomeres, is wholly membranous. It opens immediately to the left of the main copulatory process.

Immediately above the accessory sclerite of the right phallomere and hinged to its dorsal margin is another asymmetrical transverse sclerite (figs. 11, 19), the right extremity of which terminates in an abruptly deflexed pointed process. This process is immediately above the similar process of the accessory sclerite and the two processes suggest the upper and lower jaws of a pair of claspers. In a male which was about to copulate the two processes moved apart as though about to function as a clasper but the muscles (fig. 18) do not suggest such a function. This upper transverse sclerite appears to belong to the sternum of segment 10, since it has muscular connections only with the tergum of that segment.

The cerci are similar to those of the female. The epiproct and paraprocts are also similar but slightly less prominent.

## ABDOMINAL MUSCULATURE

### MUSCLES OF ABDOMINAL SEGMENT 1

In Part 3 of the present series (Walker, 1938, pp. 615-616), the sixth ventral longitudinal muscle (No. 111) was described as dividing into two branches, one of which (111b) was stated, with some doubt, to be inserted on the antero-lateral angle of the sternum of the second abdominal segment. The doubt was due to the fact that in every dissection made this slender muscle was broken and material was too scarce to permit of further dissections at that time. More recent dissections reveal the fact that No. 111b is inserted on the anterior margin of the membranous part of segment 1, laterad of the sternal sclerite but doubtless the antero-lateral angle of the sternal region (fig. 9). This is inferred from the fact that this muscle is continuous with the lateral portion of the ventral longitudinal muscle of segment 1.

The two groups of fibres, 111a and 111b, were described as branches of one muscle since they are completely contiguous throughout the length of 111a. Since 111a, however, is inserted on the metasternal apophysis, while 111b is inserted on the sternum of the first abdominal segment, the latter should be regarded as a separate, intersegmental muscle of the longitudinal ventral series.

#### 135. *Inner dorsal muscle* (figs. 8, 9, 10).

This is a continuation of the longitudinal dorsal muscles of the thorax, following No. 112. It is a broad flat muscle arising on the antecosta of the tergum of segment 1 and inserted on the antecosta of the tergum of segment 2. Each muscle is but narrowly separated mesally from its fellow and the two muscles cover practically the entire tergal region except the rounded lateral lobes.

#### 136. *Outer dorsal muscles* (fig. 16).

Three small groups of few and fine fibres, arising on the anterior half of the tergum and inserted on the antecosta of the following tergum. There is a mesal group at the mesal margin of 135, a lateral group close to the lateral margin of the same muscle, and a sublateral group, with somewhat oblique fibres, between the other two groups but nearer the lateral.

137. *Alary muscle* (fig. 8).

Arises by a small tendon on the tergal antecosta among the lateral fibres of 135, the fibres spreading fanwise to be inserted on the ventral wall of the heart.

138. *Inner ventral muscle* (figs. 8, 9).

The greater part of this muscle, as found in the typical abdominal segments (2-6), is represented in segment 1 by the seventh ventral longitudinal muscle, No. 114, described in Part 3 of this series. This muscle arises on the metasternal apophysis and is inserted on the anterior margin of the sternum of segment 2. A small lateral slip, however, narrowly separated from 114, arises on the anterior margin of segment 1, in alignment with 111b and is inserted on the anterior margin of the sternum of segment 2, immediately laterad of the insertion of 114.

The *outer ventral muscles* (139-141, fig. 9) consist of a lateral group of fibres together with two pairs of muscles which function as retractors of the eversible sac.

The *lateral group* (139) is a very thin flat muscle arising on the anterior margin of the sternum of segment 2, somewhat mesad of the lateral margin, its fibres converging forward and somewhat laterad to their insertion on the membranous part of the sternal area of segment 1, near its antero-lateral angle.

140. *Posterior retractor of the eversible sac* (figs. 8, 9).

Arising on the anterior margin of the sternum of segment 2, in line with the mesal fibres of the outer ventral muscles of that segment (No. 150) and passing antero-mesad to its insertion on the lateral wall of the eversible sac.

These muscles appear to be the serial homologues of the mesal group of fibres of the outer ventral muscles of typical segments.

141. *Lateral retractor of the eversible sac* (figs. 8, 9).

Arising on the lateral margin of the sternal sclerite, its fibres diverging mesad to their insertion on the lateral wall of the eversible sac.

This muscle is doubtfully referred to the mesal group. Possibly it is one of the series of transverse ventral muscles, not present in the other segments in *Grylloblatta* but found in all typical segments in the Saltatoria. Maki (1938) describes a pair of transverse ventral muscles in the first abdominal segment of the phasmid *Megacrania*.

The lateral muscles include, from before backwards, an intersegmental tergo-sternal and three intrasegmental muscles, viz., a sterno-pleural, a segmental tergo-sternal and a tergo-pleural muscle. The intrasegmental tergo-sternal muscle and probably also the intersegmental tergo-sternal belong to the inner series. The others belong to the outer series and are, according to Snodgrass (1931), to be regarded as primarily tergo-sternal, their insertions being in the region of the original "pleural line," i. e., just below the spiracles.

142. *Intersegmental tergo-sternal muscle* (figs. 8, 9).

A very slender bundle of fibres extending from the postero-lateral angle of the metatergum to the antero-lateral angle of the sternum of segment 1.

This muscle corresponds to the intersegmental tergo-pleural of *Gryllus* (Snodgrass, 1933, fig. 15 B, No. 3) including probably also a part of the sterno-pleural muscle No. 6.

**143. Sterno-pleural muscle** (figs. 8, 9).

A thin flat band of fibres extending dorsad from an oblique line of origin on the lateral margin of the sternal region at its anterior end to its insertion on the pleural membrane close to the front margin.

This appears to represent Snodgrass' paratergosternal muscle, No. 4, perhaps including No. 5 (Snodgrass, *l. c.*, fig. 15 B).

**144. Intrasegmental tergo-sternal muscle** (figs. 8, 9).

The largest of the lateral group: a flat muscle with parallel fibres, its tergal attachment a little mesad of the lateral edge of 135 and near the middle of the segment, passing ventrad to its sternal attachment on the lateral margin of the sternum.

This is No. 1 in *Gryllus* (Snodgrass, *l. c.*, fig. 15 B) and the secondary segmental tergo-sternal of Ford (1923).

**145. Tergo-pleural muscle** (figs. 8, 9).

A shorter muscle than 144, of parallel fibres, arising on the tergum just behind 144, and passing ventrad, internal to the spiracle; to its insertion on the pleural membrane just below the latter.

This appears to be No. 2 in *Gryllus* (Snodgrass, *l. c.*, fig. 15 B).

There are no abdominal spiracular muscles in *Grylloblatta*.

#### MUSCLES OF SEGMENT 2

**146. Inner dorsal muscle** (figs. 8, 9).

A flat sheet of parallel fibres, arising on the tergal antecosta of segment 2 and inserted on the tergal antecosta of segment 3. It is in alignment with 135 and quite similar to the latter in its relations.

**147. Outer dorsal muscles** (figs. 8, 9).

Three minute groups of fibres as described for segment 1.

**148. Alary muscle** (fig. 8).

As described for segment 1.

**149. Inner ventral muscle** (figs. 8, 9).

A wide band of parallel fibres in alignment with 114 and 138, extending from the anterior margin of the sternum of segment 2, to the anterior margin of the sternum of segment 3 and covering the lateral fourth of the sternal area.

**150. Outer ventral muscle** (figs. 8, 9).

This muscle is divided into two very thin, flat groups of fibres, a larger mesal group and a smaller lateral group.

The *mesal group* (150a) arises on the anterior margin of the sternum of segment 3, largely beneath 149, its fibres converging forward and somewhat mesad to a short line of insertion on the anterior third of the sternum of segment 2, just mesad of the mesal edge of 149. When contracted this muscle is decidedly oblique, when extended, as in fig. 8, it appears only slightly so.

The *lateral group* (150b) is a very small and thin fan of fibres arising on the extreme lateral part of the anterior margin of the sternum of segment 3, where the cuticle is almost membranous, its fibres converging to a minute area of insertion on the lateral margin of the sternum of segment 2 about midway of its length.

The lateral muscles include from before backward an intersegmental tergo-sternal, an anterior intrasegmental tergo-sternal, a sterno-pleural, a posterior intrasegmental tergo-sternal and a tergo-pleural muscle. The tergo-sternal muscles appear to represent the inner series of lateral muscles, the sterno-pleural and tergo-pleural the outer series.

151. *Intersegmental tergo-sternal muscle* (figs. 8, 9).

A very slender bundle of fibres extending from the postero-lateral angle of the tergum of segment 1 to the antero-lateral angle of the sternum of segment 2. It is the serial homologue of 142.

152. *Anterior intrasegmental tergo-sternal muscle* (figs. 8, 9).

A tenuous group of few fibres, arising on the tergal antecosta close to the origin of the alary muscle and inserted, in common with 151, on the antero-lateral angle of the sternum.

This is the primary segmental tergo-sternal of Ford.

153. *Sterno-pleural muscle* (figs. 8, 9).

A small flat group of fibres, arising on the lateral margin of the sternum, immediately behind 152, from which it is not distinctly separated, and inserted on the pleural membrane close to the front margin of the segment.

154. *Posterior intrasegmental tergo-sternal muscle* (figs. 8, 9).

A band of parallel fibres having a tergal attachment a little mesad of the lateral edge of the inner dorsal muscle and somewhat less than midway back from the front margin, passing ventrad to its sternal attachment on the lateral margin of the sternum. It is the serial homologue of 144 of segment 1.

This is the secondary segmental tergo-sternal of Ford.

155. *Tergo-pleural muscle* (figs. 8, 9).

A band of parallel fibres arising on the tergum, immediately behind the origin of 154, and passing ventrad, internal to the spiracle, to its insertion on the pleural membrane just below the latter.

The above description of the muscles of segment 2 applies equally well to segments 3, 4, 5 and 6 and the muscles of these segments will therefore be merely enumerated.

#### MUSCLES OF SEGMENT 3 (FIG. 8)

156. *Inner dorsal muscle.*

157. *Outer dorsal muscle.*

158. *Alary muscle.*

159. *Inner ventral muscle.*

160. *Outer ventral muscle.*

161. *Intersegmental tergo-sternal muscle.*

162. *Anterior intrasegmental tergo-sternal muscle.*

163. *Sterno-pleural muscle.*

164. *Posterior intrasegmental tergo-sternal muscle.*

165. *Tergo-pleural muscle.*

#### MUSCLES OF SEGMENT 4 (FIG. 8)

166 to 175, as listed above.

## MUSCLES OF SEGMENT 5 (Fig. 8)

176 to 185, as listed under segment 3.

## MUSCLES OF SEGMENT 6 (Fig. 8)

186 to 195, as listed under segment 3.

## MUSCLES OF SEGMENT 7 (Figs 8, 10)

196 to 205, as listed under segment 3, typical in the male but modified in the female as follows:

200. *Outer ventral muscle.*

*Mesal group* (200a) arising on the anterior fourth of the sternum, mesad of the inner ventral muscle, the two muscles converging caudad to their insertion on the dorsal wall of the vagina at its base. At its origin it is contiguous with the inner ventral muscle, from which it may receive a few fibres. It appears to function as a retractor of the vagina but is the homologue of Snodgrass' *Retractor of the Spermathecal pouch* in *Gryllus* (Snodgrass, 1933, fig. 17, 2).

The *lateral group* of fibres (200b) is unmodified.

## MUSCLES OF SEGMENT 8

## FEMALE (FIGS. 8, 10)

206. *Inner dorsal muscle*, as described for segment 2.

207. *Outer dorsal muscle*, as described for segment 2.

208. *Alary muscle*, as described for segment 2.

209. *Inner ventral muscle.*

Arising on the anterior margin of the sternum, in continuity with 199, but directed meso-caudad, with converging fibres, to its insertion on the valvifer. It appears to function as a retractor of the first valvulae.

This muscle together with No. 199, with which it is combined in *Gryllus*, is the *retractor of the ovipositor* of Snodgrass, (1933, fig. 17, No. 1). In *Ceuthophilus* according to Ford (1923) it is like that of *Grylloblatta* in being separate from No. 199, but differs in being inserted on the inferior intervalvula instead of the valvifer. Both, however, are parts of the sternum of segment 9.

210. *Outer ventral muscle.*

A single pair of muscles, doubtless representing the mesal group, arising on the sternum near its lateral margin and just mesad of the sternal attachment of the posterior segmental tergo-sternal muscle (213); passing caudo-mesad to its insertion on the dorsal wall of the vagina behind the duct of the spermatheca.

This muscle has no exact equivalent in *Gryllus* but appears to be represented in *Conocephalus* by a muscle which Ford (1923) terms the secondary transverse muscle of segment 8.

211. *Intersegmental tergo-sternal muscle.* Typical.

212. *Anterior intrasegmental tergo-sternal muscle.* Typical.

213. *Sterno-pleural muscle.* Typical; not clearly separated from 212 except in its pleural insertion.

214. *Posterior intrasegmental tergo-sternal muscle.* Typical.

215. *Tergo-pleural muscle.* Typical.

216. *Tergal muscle of the first valvula.*

A stout muscle with subparallel fibres, arising on the anterior surface of the upper part of the lateral apodeme of segment 9 and passing ventrad to its insertion on the mesal surface of the basivalvula. Although the apodeme on which this muscle arises is described as an enlarged part of the antecosta of segment 9, this muscle is probably one of the lateral series of segment 8, since it is inserted on the basivalvula which arises on that segment. Ford (1923) describes it as a tergo-sternal muscle of segment 8 and it appears in her figure as arising in that segment. It is the "tergal muscle of the first valvifer" of Snodgrass (1933).

217. *Adductor of the first valvula.*

A short muscle arising on the mesal surface of the basivalvula and inserted mesally on the base of the blade of the first valvula. It is not present in *Gryllus*.

## MALE

206. *Inner dorsal muscle.* Typical (see segment 2).

207. *Outer dorsal muscle.* Typical.

208. *Alary muscle.* Typical.

209. *Inner ventral muscle.* Typical.

210. *Outer ventral muscle.* Mesal group typical, lateral group absent.

211. *Intersegmental tergo-sternal muscle.* Typical.

212. *Anterior segmental tergo-sternal muscle.*

As described for segment 2, but stouter than in the more anterior segments.

(213. *Sterno-pleural muscle* absent.)

214. *Posterior segmental tergo-sternal muscle.* Typical.

215. *Tergo-pleural muscle* (fig. 8, 10). Typical and but little shorter than 214. The spiracle lies at about its hind margin instead of beneath it.

Nos. 216 and 217 have no homologues in the male.

## MUSCLES OF SEGMENT 9

## FEMALE

218. *Inner dorsal muscle* (figs. 8, 10).

These are restricted to the medio-dorsal half of the tergum but are otherwise as described for segment 2.

No outer dorsal muscles were found.

The ventral and lateral muscles all take part in the movements of the ovipositor. It will be convenient to describe the lateral muscles first, viz., the three following (Nos. 220-222):

219. *Inner ventral muscle* (fig. 10).

A slender muscle arising on the valvifer, extending meso-dorsad and then caudad along the sternum of segment 10, close to the median line, to its insertion on the base of the paraproct. This muscle thus appears to represent the combined inner ventral muscles of segments 9 and 10. It was not observed by Snodgrass in *Gryllus* but is described and illustrated by Ford in this genus.

220. *Superior tergal muscle of the third valvula* (figs. 8, 10).

A large flat muscle, arising on the dorso-lateral part of the tergum, external to 218, and meeting the antecosta below, its fibres converging

ventro-caudad to their insertion on the superior apophyses of the third valvula.

Although not mentioned by Snodgrass this muscle, according to Ford, is well developed in *Gryllus* and other Ensifera. (Ford, 1923, figs. 21, 22, 23, ttg 9).

221. *Inferior tergal muscle of the third valvula* (fig. 10).

A stout muscle arising on the lateral apodeme and passing dorso-caudad with convergent fibres to its insertion on the under surface of the superior apophyses of the third valvula.

This is the *posterior tergal muscle of the second valvifer* of Snodgrass.

222. *Inner tergal muscle of the third valvula* (fig. 10).

A thick spindle-shaped muscle, arising on the thickened lateral part of the tergal antecosta, mesad of 216, and passing caudo-ventrad to its insertion on the curved bar formed of the united inferior apophyses of the third valvulae.

This is Snodgrass' *anterior tergal muscle of the second valvifer*.

The two remaining muscles of segment 9 are wholly sternal. These are the following (Nos. 223 and 224):

223. *Intervalvular muscle of the valvifer* (fig. 10).

A cylindrical muscle of parallel fibres, arising partly on the dorsal cuticle between the superior apodemes of the third valvulae and partly on a thin median septum, connected above with the cuticle, and separating the two muscles; and passing latero-ventrad to its insertion on the upper part of the valvifer.

This is Snodgrass' *intervalvular muscle of the first valvifer*.

224. *Muscle of the second valvula* (fig. 10).

A short muscle arising on the basal part of the third valvula, just posterior to the origin of No. 223, its fibres converging ventrally to their insertion on a rounded prominence on the united bases of the second valvulae.

This muscle, according to Snodgrass, is absent in *Gryllus*, in which the second valvulae are vestigial, but is well developed in *Scudderia*.

#### MALE

218. *Inner dorsal muscle* (figs. 21, 13, 15).

These muscles are asymmetrically developed. They arise on the mesal half of the antecosta of segment 9, their mesal edges meeting, and pass divergently latero-caudad, leaving a V-shaped median space in which the rectum is exposed (fig. 12). Both muscles are inserted on the anterior margin of the tergum of segment 10, but the insertion of the right muscle is comparatively narrow while that of the left is much wider, continuing along the ventro-lateral extension of the tergum of segment 10, which functions as the base of the tergal arm (fig. 15). This muscle appears to function as a depressor of the left tergal arm.

No outer dorsal muscles were recognized.

219. *Inner ventral muscle* (fig. 17).

A slender muscle arising on the anterior margin of the sternum of segment 9, close to the median line, and passing caudad between the vasa deferentia and over the ejaculatory duct and the sternum of segment 10 to its insertion mesally on the base of the paraproct.

The lateral muscles are represented by the following pair only:



**220. *Flexor of the coxal plate* (figs. 12, 13).**

These muscles are asymmetrically developed but, on both sides, arise dorso-laterally on the tergum of segment 9, overlapping the lateral portions of the inner dorsal muscle.

The right muscle (220 r) is large and strong and overlaps the greater part of the inner dorsal muscle of the same side. Its fibres converge from a broad area or origin to their insertion on a stout tendon attached to the dorsal angle of the base of the right coxal plate.

The left muscle (220 l) has a much smaller area of origin, which covers but little of the dorsal surface and overlaps very little of the inner dorsal muscle. Its convergent fibres have a tendinous insertion on the dorso-lateral angles of the left coxal plate.

Since the coxal plates are the homologues of the third valvulae of the female it seems reasonable to infer that the flexor muscles of the former (the only muscles they possess) are the representatives of the major depressor muscles of the third valvulae, which are similar in origin and insertion.

The remaining muscles of segment 9 (Nos. 225 and 226) belong to the ventral series but cannot be homologized with any of the muscles in the female. They consist of the principal muscles which control the movements of the phallomeres and, as one would expect from the exoskeletal parts, they are asymmetrically developed.

**225. *Outer ventral muscles of the phallomeres* (figs. 13-16, 18).**

The right muscle arises on the sternum, chiefly along the anterior margin, its origin extending somewhat to the left of the middle line. The fibres converge obliquely to the right and are inserted on the extremity of the right hook of the apophysis of the right phallomere.

The left muscle is a very large muscle, covering at least two-thirds of the sternal area and overlapping a part of the right muscle. The line of origin extends from the anterior margin of the sternum on the left side of the middle line, obliquely across the sternum almost to the posterior margin on the extreme right, the fibres converging sinistrad to their insertion on an oval sclerite close to the base of the left tergal arm, with which it forms a sort of articulation.

**226. *Inner ventral muscles of the phallomeres* (figs. 18, 19).**

The right muscle is a large, flat, fan-shaped muscle, arising on the sternum along the anterior margin, just internal to the insertion of the corresponding outer muscle, its line of origin extending from about the middle line to the lateral margin, the fibres converging sinistrad to their insertion on the left hook of the apophysis of the right phallomere.

The left muscle is a thin flat sheet of much finer fibres than the right muscle, arising on the anterior margin of the sternum, left of the middle line, its fibres converging to their insertion on a thinly sclerotized area on the dorsal surface of the base of the left phallomere, close to the mesal margin.

Additional muscles of the right phallomere, not connected with the ninth sternum are:

**227. *Protractor of the copulatory process* (figs. 16, 18, 19).**

A bundle of parallel fibres arising on the basal rim of the right phallomere, which forms a sheath for the copulatory process, and passing forward to its insertion on the left hook of the apophysis.

228. *Depressor of the accessory sclerite of the right phallomere* (figs. 18, 19).

Arising on the left hook of the apophysis, its divergent fibres inserted on the accessory sclerite, the thickest part being attached to the right extremity, which forms the base of the free external process.

MUSCLES OF SEGMENT 10 AND TERMINAL PARTS

229. *Abductor of the cercus* (figs. 10, 18, 21, 23).

A relatively broad flat group of fibres arising along the anterior margin of the lateral wall of the tergum of segment 10 and extending caudad along the inner surface of the tergum to its insertion on the lateral margin of the base of the cercus.

230. *Levator of the cercus* (figs. 10, 18, 21).

A small flat muscle arising mesally on the tergum of segment 10, its fibres converging laterad to their insertion on the dorso-mesal margin of the base of the cercus.

231. *Adductor of the cercus* (figs. 10, 18, 21, 23).

Arising latero-dorsally on the basal part of the tergum of segment 10, its fibres converging slightly to their insertion on the mesal margin of the base of the cercus just below the insertion of 230.

232. *Adductor of the paraproct* (figs. 8, 10, 21, 22).

A bundle of parallel fibres arising dorsally on the tergum of segment 10, mesad of 231 and somewhat anterior to its origin, passing ventro-caudad beneath 230 to its insertion on the mesal edge of the paraproct close to its junction with the epiphallus.

The dilators of the rectum have not been satisfactorily studied and will be considered, if possible, in a later section dealing with the digestive system.

The following muscle occurs in the male only.

233. *Tergo-sternal muscle of segment 10* (figs. 17, 18, 19).

A relatively large muscle having a wide origin on the upper transverse sclerite (which appears to belong to the sternum of segment 10). Each muscle is composed of a stout compact proximal part in which the fibres are somewhat twisted, and a more slender distal part with parallel fibres, the fibres being apparently bound by connective tissue at the junction of the two parts. The two muscles are confluent proximally but the fibres of each pass caudo-laterad to their insertion on the lateral walls of the tergum of segment 10, just beneath 228. Doubtless these muscles play some part in the copulatory mechanism since they are not present in the female, but their exact function is obscure.

DISCUSSION

The exoskeleton and musculature of the abdomen of *Grylloblatta* present several features in which it is more primitive than other orthopterous forms. These are as follows:

(1) The first segment is not reduced and is not fused with the metathorax but is freely movable, its muscular connections with the metathorax being similar to those with the second abdominal segment. Associated with this feature is the presence of a distinct third spina, as described in the third part of this series (Walker, 1938).

(2) In the female there is no enlargement of either the seventh or eighth sternum to form a specialized subgenital plate. In the Blattaria, Mantaria and Isoptera the seventh sternum is enlarged and the eighth reduced, while in the Phasmaria and Saltatoria the eighth is enlarged.

(3) In the male there is a pair of movable styligerous coxal plates or limb bases articulated with the hind margin of the ninth sternum. These are the male homologues of the third valvulae of the female and are moved by a pair of flexor muscles which appear to be homologous with the superior tergal muscles of the third valvulae. In other Orthoptera the coxal plates are fused with the sternum of segment 9, forming a coxosternum which may or may not bear styli.

(4) While the cerci of certain orthopteroid groups are multi-articulate (Blattaria, Mantaria, Isoptera) they are more or less reduced, with relatively little mobility of the segments, whereas those of *Grylloblatta* are more elongate and flexible, recalling the cerci of certain Plecoptera and the Thysanuran genus *Campodea*.

A fifth primitive feature, shared with the Blattaria and Mantaria, is the simple bilobed structure of the phallus (Snodgrass, 1937) and the lack of any differentiation of an aedeagus.

Mention may be made also of the large exerted ovipositor, which recalls that of the more primitive Saltatoria of the suborder Ensifera, but is less specialized in so far as the valvulae are less coherent, the third pair being apically separate and projecting distinctly beyond the other pairs. The absence of the inferior intervalvula and the imperfect development of the superior intervalvula are probably secondary features.

Specialized features of the abdominal wall and genitalia of *Grylloblatta* are (1) the presence of an eversible sac on the sternum of segment 1, recalling the paired structures of this type found in Thysanura and Symphyla; (2) the complex asymmetrical copulatory mechanism of the male, which involves the coxal plates, phallomeres and the tergum of segment 10. Claspers appear to be formed by the right coxal plate and the left tergal arm of segment 10, while the broad left coxal plate serves as a subgenital plate. Most of the left phallomere is modified into a long coiled retractile membranous sac of unknown function. The asymmetrical modification of the phallomeres and their oblique position in relation to each other, together with the lack of differentiation of an aedeagus, strikingly parallel the similar modifications in the Blattaria and Mantaria, but are not regarded as evidence of direct phylogenetic relationship to these groups.

The musculature of the body wall is in some respects primitive, in others it gives evidence of reduction. The inner dorsal and ventral muscles exhibit a primitive condition in so far as they form with the corresponding thoracic muscles continuous sheets of parallel fibres extending to the bases of the paraprocts and interrupted only by their regular segmental attachments. Ford (1923) has pointed out that the arrangement of the inner dorsal muscles, which form an unbroken median band, is most like that of the Blattaria, while the lateral position of the inner ventral muscles, which are widely separated mesally, recalls the Saltatoria. The outer dorsal and ventral muscles are also more like those of the Saltatoria in being divided into a few small isolated bundles, but are also greatly reduced or even vestigial. The lateral group of the outer ventral muscles is perhaps the homologue of

the sterno-pleural of the Blattaria. The transverse ventral muscles commonly present in the Saltatoria appear to be absent in *Grylloblatta*, as are also the paratergal muscles.

The lateral muscles are somewhat feebly developed, as would be expected in an insect in which respiratory movements are lacking. The complete absence of spiracular muscles is especially noteworthy in this connection. In its lateral muscles *Grylloblatta* is most like the members of the suborder Ensifera of the Saltatoria, as indicated by comparison with the figures of Ford (1923) and Ander (1939). It resembles most of the forms figured by these authors in having two intrasegmental tergo-sternal muscles, a smaller anterior and a larger posterior. The intersegmental tergo-sternal muscle is found in most of the Gryllidae but not in the Tettigonioidea. In the Gryllidae it is generally divided into dorsal and ventral parts, the two meeting at an intermediate line of insertion on the pleuron. *Nemobius*, however, resembles *Grylloblatta* in lacking this pleural insertion. A similar pleural insertion is generally present also in the third intrasegmental tergo-sternal muscle, when this is fully developed. e. g., in *Gryllus*, *Nemobius* (Ford, 1923) and *Endocous* (Ander, 1939). When the ventral part of this muscle is lacking, as in *Oecanthus* and *Grylloblatta*, the dorsal part becomes the tergo-pleural muscle. Sterno-pleural muscles appear to be constantly present in the anterior half of the segment, as in *Grylloblatta*, but are sometimes subdivided into two or more groups of fibres.

In its lateral muscles *Grylloblatta* shows less resemblance to the other orthopteroid groups than to the Ensifera. The highly developed muscles of the Acrididae, as described by Snodgrass (1935) need not be used here as a basis for comparison, since this family represents another branch of the Saltatoria, much more specialized than the Ensifera. Typical segments of the phasmid *Megacrana* resemble those of *Grylloblatta* in the presence of small intersegmental tergo-sternal muscles with similar connections (Maki, 1938), but the long series of short tergo-sternal and tergo-pleural bundles have little in common with the muscles of *Grylloblatta*. In the Blattaria the lateral muscles are reduced in number but more specialized. Only the posterior tergo-sternal is well developed, the anterior being sometimes, if not usually, absent. The intersegmental tergo-sternal is much stronger and more oblique than in the other groups mentioned, its tergal attachment being much farther forward. There is no tergo-pleural muscle and the only sterno-pleurals are oblique intersegmental muscles, which are inserted on the so-called pleural plates of the segment following the one on which they take origin.

The muscles of the ovipositor are most like those of the Ensifera, as would be expected, but differ in the place of origin of the tergal muscle of the first valvula which is on the lateral apodeme of segment 9 instead of the lateral apodeme or antecosta of segment 8. Muscle 217 is peculiar to *Grylloblatta*, so far as known.

The attachments of the inner ventral muscles to the valvifer in *Grylloblatta* confirm the view that this sclerite is a part of the ninth sternum. The muscles of this series that arise on segment 7 are inserted on the antecosta of segment 8; the following pair, arising on segment 8, are inserted on the valvifer; and the last pair, arising on the valvifers, are inserted on the bases of the paraprocts.

In *Centrophilus*, according to Ford, the arrangement is similar except that the muscles arising on segment 8 are inserted on the inferior intervalva, although the last pair arises on the valvifers and is inserted on the bases of the paraprocts as in *Grylloblatta*. In this arrangement the strict continuity of the series is broken by the insertion of one of the pairs on the inferior intervalva, although the latter, like the valvifer, is a part of the ninth sternum.

In *Gryllus* the muscles arising on the seventh sternum are united with those of the eighth, the composite pair thus formed being inserted on the sclerite that has been generally regarded as the valvifer (Snodgrass, 1935; Walker, 1919). According to Ford, however, this sclerite is a composite of the valvifer and the basivalvula and this view appears to be correct for the following reasons:

(1) Unlike the valvifer of *Grylloblatta* and the Tettigonioides it extends forward upon the 8th segment in the otherwise membranous region at the base of the first valvula, and this anterior part is delimited from the posterior part, which lies within the 9th segment, by an internal ridge in the intersegmental line. These parts are well illustrated by Snodgrass (1935, p. 50, fig. 21) in various Gryllidae. The anterior part of this sclerite in our opinion, is the basivalvula and is evidently the same structure as the part labelled 1 Vlf (First Valvifer) in Snodgrass' figure (21 D) of the ovipositor of a young nymph of *Neoconocephalus*.

(2) The muscle termed by Snodgrass "tergal muscle of the first valvifer" is inserted on the anterior process of the basivalvular part of the composite sclerite, and this muscle is apparently the homologue of No. 216 of *Grylloblatta*, which is inserted on the basivalvula.

The posterior part of the basivalvula-valvifer, labelled "y" in Snodgrass' figures, lies in the 9th sternal region and is the true valvifer. The small lateral sclerite "x" of the 9th segment may also be fused with the valvifer, as shown in Snodgrass' figures of *Neoxabia* and *Cyrtoxipha*, but appears to be a special feature of the Gryllidae. In *Grylloblatta*, in which the valvifer is free from neighbouring sclerites, it appears very clearly in the last two nymphal instars as the lateral part of the ninth sternum. This interpretation is further confirmed by the articulation with this sclerite of the nymphal coxal plate which becomes the third valvula.

The internal ventral muscle of *Gryllus* arising on segment 7 is not inserted on the valvifer as here interpreted but on the basivalvula. This we believe to be a secondary shifting of this muscle's insertion, associated with the fusion of the two sclerites into a single functional unit.

One other form, *Gryllotalpa*, may be mentioned as giving further evidence that the valvifer is of ninth sternal origin. In association with its subterranean habits the ovipositor of *Gryllotalpa* has wholly disappeared and the 9th sternum has regained its primitive form, resembling that of the male. Accordingly the internal ventral muscles have resumed their primitive relations, and here we see clearly (v. Ford, l. c., pl. XV, fig. 24) that the muscles arising on segment 8 are inserted on the antecosta of segment 9 and these are followed by well-developed muscles extending from the antecosta of segment 9 to the bases of the paraprocts.

With regard to the muscles of the male terminalia the most significant feature is the presence of muscles arising on the ninth tergum which

function as flexors of the coxal plates. These appear to be the male representatives of the superior tergal muscles of the third valvulae of the female. *Grylloblatta* is the only known orthopteran in which these muscles occur in the male, since in other Orthoptera the coxal plates are fused with the ninth sternum. There are no muscles inserted on the styli.

The complex and asymmetrical muscles of the phallus are chiefly concerned with the movements of the large copulatory hook developed from the right phallomere. They are divisible into two groups, those arising on the ninth sternum and those whose attachments are wholly within the phallus itself, the latter being restricted to the right phallomere. No attempt has been made to compare these muscles with the phallic muscles of other Orthoptera, since the special features of the phallus of *Grylloblatta* have probably arisen independently of other orthopteroid groups.

The modifications of the tenth segment of the male as part of the copulatory mechanism appear to be unique among the Orthoptera. The specialization of a part of the left inner dorsal muscle for insertion on the base of the left tergal arm is noteworthy, as is also the presence of the muscles which have been doubtfully interpreted as tergo-sternals of the tenth segment.

### CONCLUSIONS

The present study of the abdominal exoskeleton and musculature of *Grylloblatta* has not materially altered the views long held by the writer concerning its phylogenetic relationships. There seems to be no reason to doubt that its nearest affinities are with the most primitive representatives of the suborder Ensifera, as stated by Crampton (1927).<sup>2</sup> We are not prepared, however, to include the Grylloblattidae in the same suborder as the Ensifera, as proposed by Crampton (*l. c.*) and, doubtless independently, by Handlirsch (according to Ander, 1939), and Weber (1933). According to this view the Caelifera, which include the remaining families of Saltatoria, are more widely separated from the Tettigonioidea and Grylloidea than are the Grylloblattidae, a point of view that ignores the many important differences which exist between the Grylloblattidae and the Saltatoria as a whole, e. g., the very different type of phallus and the persistence of many primitive characters that are not found in any of the Saltatoria. Admitting that the Ensifera and Caelifera are widely separated and that the former "as a separate stock can be traced as far back as the Upper Carboniferous" (Zeuner, 1939), we concur with Ander's view that the Grylloblattidae should be treated as a group apart from the Saltatoria. Whether it should be given ordinal rank, however, is largely a matter of convenience and will not be discussed at the present stage of our investigation.

As to *Grylloblatta's* relationships with the other orthopteroid orders, little need be said at present. It shows little resemblance to the Phasmaria in the abdominal musculature, although sufficient similarity exists in the external features of the terminal segments (Walker, 1919, 1922; Snodgrass, 1937) to warrant a fairly close association with this group. The blattoid complex is also definitely farther removed from

<sup>2</sup>Crampton uses the term Euorthoptera for the Ensifera together with Grylloblattidae.

*Grylloblatta* than are the Saltatoria. There is the similarity in the phallus and the retention in both groups of such primitive characters as the segmented cerci and the broad continuous layers of the inner dorsal and ventral muscles, but the special features of the blattoid groups, such as those of the lateral muscles and the genital segments, are quite different from the corresponding parts in *Grylloblatta* and indicate a different line of descent.

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## THE GENUS *THYRIDIA* (Lepidoptera, Ithomiinae)

WM. T. M. FORBES,

Department of Entomology, Cornell University,  
Ithaca, New York

The genus *Thyridia* (*Methona*) is in complete confusion in the majority of American collections, primarily because there are three species which show practically no distinction in color and pattern nor in distribution (see map), while within each there is parallel variation in the ground tint. The other two familiar species show tangible differences in pattern and have generally been correctly determined, though one is very close in structure to a member of the first three. Of these three, one is new, and in its highland Ecuador race is larger than any Ithomiid hitherto known; and we describe two further species from a couple of females in our collection and a male in the Carnegie Museum collection, that are even larger.

D'Almeida has recently (Rev. de Ent., 11:760, 1940) proposed the new genus *Gelotophye* for *mystica*, one of the three confusion species, but the new ones fit so exactly between it and *confusa* that it can certainly not be held as a genus. Possibly it may remain as a subgenus on the basis of the modified last tergite and very long saccus and aedoeagus, but if so the new *grandior* must be added to it.

I have already published a note on the relationships of this genus (Ent. News, 52:1, 1941), which with the very similar *Aprotopus* forms a transition between the two main groups of Ithomiinae. It differs from *Aprotopus* by the "trifid" cubitus of hind wing, from all other Ithomiinae by the large size and *Ituna*-pattern, honey yellow with heavy black borders and two (rarely only one) black bands across the fore wing and one or none across the hind wing. In connection with published descriptions, and particularly Fox's key to females (Trans. Am. Ent. Soc., 66:174, alternative 23) note that the female hair-pencil is not really diagnostic of the genus, but is limited to *psamathe* and *confusa*, *singularis*, *grandior*, and possibly *maxima*; in *mystica* and *nigerrima* there is no pencil, though Sc is more sinuous than usual in Ithomiine females.

I acknowledge help from various collections and entomologists whose material has been studied, either directly or through Mr. Fox, and particularly Mr. N. D. Riley of the British Museum. I owe him for information on the identity of several names, and also for a large amount of data on distributions, without which the map would have been much more fragmentary. I much regret that conditions of travel have prevented a closer collaboration. In the matter of the name *curvifascia* I have not followed him (in lit.). Riley would apply it to a series of properly marked specimens of *mystica* in the British Museum from the Upper Amazon, but we have no material of this pattern from



near the type locality (eastern Ecuador) and parallel forms of *confusa* or even *grandior* cannot be excluded. If the type should turn out to be an aberration of *mystica* or *grandior*, it would take priority, and the corresponding normally colored specimens would have to fall to the status of a *var. norm.*

The following key is based on characters that can be seen without dissection. The figures show a few further genitalic characters, notably the long saccus and lobed valve of *mystica*<sup>1</sup> and the very long aedoeagus of both *mystica* and *grandior*. In d'Almeida's paper (op. cit.) he refers by some accident to the eighth tergite as "tegumen"<sup>2</sup> and calls the uncus absent. In fact the tegumen, while slender and not heavily chitinated, is perfectly distinct, and bears a small but distinct uncus. This is a mere hairy knob in the majority of species, but in *mystica* it is a little larger and emarginate (fig. 4) while in the new *maxima* it is quite well developed and deeply bifid (fig. 1).

#### KEY TO SPECIES

1. Abdomen yellow beneath, striped with black, costa of hind wing yellow, not cut with black at humeral vein, border of hind wing even and not broad, with no trace of a black band across the wing (Pernambuco etc.)<sup>3</sup>. . . . . **singularis**  
 Abdomen black beneath with a double row of white spots, at least on terminal segments, above also with conspicuous white spots, and the yellow limited to a narrow lateral line; costa of hind wing heavily black over humeral vein or more extensively, even wholly, black; hind wing with a black band across it at end of cell, or at least a tooth at Cu<sub>1</sub>. . . . . 2
2. Male; fore tibio-tarsus white and reduced to two minute segments. . . . . 3  
 Female; fore tibia slender, black, the tarsus enlarged and distinctly segmented. 9
3. Bar across end of cell of fore wing right-angled over angulation of discocellulars, its continuation to outer margin leaving a hyaline spot in upper outer angle of cell Cu<sub>1</sub>, and all black markings very narrow, the outer margin around anal angle hardly narrower than the rest; male fore tibio-tarsus longer than femur and trochanter together; R<sub>1</sub> free, but last tergite not enlarged. . . . . **maxima**  
 Bar across end of cell thicker and straight, its continuation reaching border at vein Cu<sub>1</sub> or higher; border at anal angle much narrower than bands across cell; male fore tibio-tarsus (with one exception) shorter. . . . . 4
4. Fore wing with Sc and R<sub>1</sub> anastomosing (one exception seen); yellow costal spot on hind wing below practically in contact with humeral vein; eighth tergite short and shallowly truncate, leaving most of valves exposed (*Thyridia*). . . . . 5  
 Fore wing with Sc and R<sub>1</sub> separate; yellow costal spot of hind wing smaller, not nearly reaching humeral vein; last tergite much enlarged and hood-like, covering apices of valves (*Gelotophye*). . . . . 8

<sup>1</sup>The lobe on the valve is often exposed in specimens of *mystica* in which the two spines of the eighth tergite are tucked in, giving a resemblance at first glance to *confusa*.

<sup>2</sup>I follow Pierce's restriction of this term to the ninth tergite, excluding the uncus, and believe d'Almeida intended the same. The term goes back to Hübner, 1820 (as "tegmen"). I assume Buchanan White failed to give Hübner credit in reviving it with the spelling now current (1877), for more or less the same reason that he writes a few pages further on: "it need hardly be remarked that the genera [Scudder's], as Hübnerian, are of no value"!

<sup>3</sup>Sex structures not examined, perhaps primitive or similar to *maxima*. The upper side of the abdomen is normally solid black, but a specimen in the Reading Museum shows white subdorsal dots.

5. Hind wing below with upper edge of discal cell and of cell  $M_1$  overlaid with white scaling; antemedial bar of fore wing typically oblique and nearly parallel to outer fascia, running through to costa; black in base of cell  $Cu$  of fore wing running out along vein  $Cu_2$  a third way to margin; hind wing with transverse fascia at end of cell weak or absent, typically represented by a triangular extension of the black border along vein  $Cu_1$  (*themisto*).....6
- Hind wing below without white scaling along costal side of transparent areas; transparent area below cell of fore wing running in practically to base of cell  $Cu_2$ ; normally with a black band across cell of fore wing perpendicular to costa and a complete band across hind wing (*confusa*).....7
6. Bands broader, vein-lines narrower (Bahia).....t. *megisto*  
Bands narrower, vein-lines broader (Pará<sup>4</sup> to Argentina).....t. *themisto*
7. Black band across cell of fore wing incomplete or absent; bands at ends of cells less than 2 mm. wide (Ecuador to northern Peru).....c. *psamathe*  
Black band across cell of fore wing complete and strong, the other bands more than 2 mm. wide (Colombia to Bolivia and Pará).....c. *confusa*
8. Last tergite ending in two subdorsal chitinous teeth.....*mystica*  
Last tergite ending in enormous rounded lateral lobes, each bearing a white patch.....*grandior*
9. Hind wing with a hair-pencil in upper part of cell, as in male, though weaker, 10 Hind wing without hair-pencil;  $Sc$  and  $R_1$  free.....11
10. Fore wing with  $Sc$  and  $R_1$  anastomosing (*themisto* and *confusa*).....5  
Fore wing with  $Sc$  and  $R_1$  free; a larger species.....*grandior*
11. Vaginal plate in a deep concavity, over 1 mm. across; the 7th sternite heavily bristled in front of it.....*nigerrima*  
Vaginal plate showing a narrow ridge in front of vaginal opening, and heavily bristled behind it; 7th sternite very lightly bristled.....*mystica*

### **T. themisto** Hbn.

Figures 7, 8, 9

Lower Amazons to northern Argentina and Uruguay. Race *megisto* is normal from Bahia, and Riley reports it to me from Maranhão, while the specimen or two I have seen from Pará approach the type form from Rio and south. The distribution of the species is that of *Danaus erippus*, *plexaure* and *gilippus*—common in southern Brazil, and reaching its limit just around Pará.

### **T. confusa** Btl.

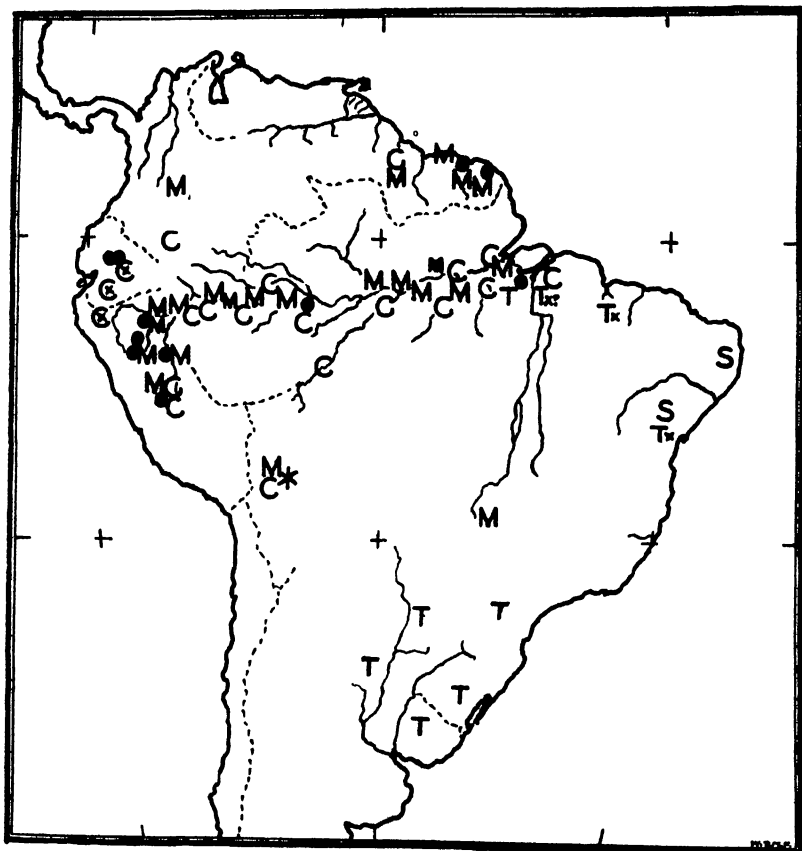
Figures 13, 14

This was intended to be a substitute name for *psidii* Cr. nec L. (i. e. *grandior*), but fortunately a type was cited from Tapajoz, and fixes the name for the more familiar species. *Psamathe* G. & S. was based on lightly marked specimens which had lost the bar across the cell. If we widen the name to include specimens with more or less distinct bar, as Talbot did in describing the synonym *denigrata*, it may be treated as a race in the eastern Andes from Ecuador to northern Peru. It intergrades eastward in Ecuador with the typical form.

The female can be easily separated from all but the preceding species by the vaginal plate, which is pointed in front and preceded by a high bristly eminence of the 7th sternite, and is widened behind, where the following species are all narrowed by the 7th sternite swinging around

<sup>4</sup>Pará specimens approach t. *megisto*.

and nearly meeting behind it. Since the map was drawn I have recognized females in the National Museum from near Santa Cruz, Bolivia and Vallicito, Argentina, which extend the range substantially. They have nearly the pale Bolivian coloring.



## DISTRIBUTION RECORDS FOR THYRIDIA

T—*themisto*  
Tx—*t. megisto*  
C—*confusa*  
Cx—*c. psamathe*

M—*mystica*  
●—*grandior*  
S—*singularis*  
\*—*maxima*

*Confusa* also varies racially in the ground color. In typical specimens the hind wing is bright yellow, visibly brighter than the fore wing, which is also decidedly yellow. We have specimens from Ampiyacu, near Pebas, and Borba, Amazonas, La Chorrera, Putumayo District, and San Nicolas to Azupizú, Camino del Pichis, Central Peru—all at low altitudes; but a block of four specimens from the Rio Songo, Bolivia (Fassl) are much paler straw color, with the hind wing no darker than the fore wing. Unlike *psamathe*, the black markings of

this form are not reduced, and unlike the corresponding form of *grandior*, specimens are no larger than the typical race. We do not know if this is a race or an ecological "subspecies." Other Bolivia specimens approach the typical coloring.

### *Thyridia maxima* new species

Figures 1, 2, 3

Markings fundamentally as in other species of the genus, the bar across cell of fore wing and across end of cell and  $Cu_1$  of hind wing being narrow but even, with no tendency to interruption. Body marked as in *confusa* and *mystica*, including the black under side of abdomen with white subventral spots. Yellow on club of antenna the shortest of any specimens at hand (7 segments, against 9 to 12), but perhaps variable.

Wings deep honey yellow, as in *psamathe*, darker than in the remaining species; markings black, rather even in width on the whole, the outer border thickened to twice its width at apex and below  $Cu_1$ , as usual, but not thinned around anal angle, being  $1\frac{1}{2}$  mm. wide at the narrowest. Inner border filling cell  $Cu$  out to the fork of vein  $Cu$ , then abruptly narrowed to less than half width of cell, and tapering to anal angle (unlike the other species); bar across cell 2 mm. wide, stopping at R, at end of cell about the same width, starting from costa, right-angled on discocellulars (unique), sharply toothed out on  $M_1$ , then running diagonally across  $Cu_1$  to border, widening gradually to border as usual, but not filling outer angle of cell  $Cu_1$  (unique). Hind wing of the same deep honey yellow, the border slightly wider, as usual, but leaving a wide postmedial hyaline yellow area in Cell R, where *themisto* is opaque white below, and the other species are black (unique); bar across end of cell nearly 2 mm. wide at narrowest, a little widened at lower angle of cell, and gradually but greatly widened to inner margin as usual. Under side similar, with the usual submarginal white spots; hind wing with a small white humeral spot, a small white and yellow dash beyond humeral vein and the upper edges of the hyaline areas finely edged with white. Expanse 95 mm.

Fore tibia and tarsus rather distinct, together definitely longer than femur with trochanter (unique) and contrastingly white; fore wing with  $R_1$  free; female hair-pencil unknown, (most probably present as in *singularis*); male genitalia (figs. 1-3) distinctive. Last tergite (fig. 3) very large, but not specially sclerotized, not covering the genitalia proper; uncus large for the genus, deeply bifid, with two separate hairy tufts on the lobes; transtilla broad and irregular, but not well sclerotized; juxta roundly emarginate, as in *grandior*; valves widening greatly to apex, where they are irregularly and, obliquely truncate, with a small but sharp apical hook. Saccus and aedoeagus about mid-proportional in length between *themisto* or *confusa* and *grandior*.

A very distinct species combining the primitive features of typical *Thyridia* and *Gelotophye*, with some additional ones of its own.

Incachaca, Bolivia, March 1921, alt. 2500 M., J. Steinbach; type male in coll. Carnegie Museum. I cannot find this place on the map, but it is doubtless near Cochabamba, and is the highest from which I have seen any *Thyridia*.

***Thyridia nigerrima* new species**

Figure 15

Markings as in other species of the genus, very heavy and even in breadth. Bar across cell very thick, 3 mm. broad, much extended basally in cell Sc and not crossing Sc; bar at end of cell 5 mm. broad, a little narrowed below cell; border continuing broad to anal angle, where it is still 3 mm. broad, a little narrower just above where the band across cell joins it. Inner margin black up to cell as far as fork of Cu, then sharply narrowing to anal angle, where there is only transparent smoky scaling above A just before the outer border. Hind wing with border broad, the bar at end of cell equally broad, and widening strongly to its junction with border. Under side similar, with the usual white admarginal spotting, costa of hind wing solid black with no yellow beyond humeral vein (unique) and the single white basal spot small. Expanse 95 mm.

Female genitalia (fig. 15) with vaginal plate transversely elliptical, over 1 mm. wide, concave, with the vaginal opening at its middle (unique); 7th sternite large, not much bulging, heavily bristled, enclosing the plate even more closely behind than in *mystica*.

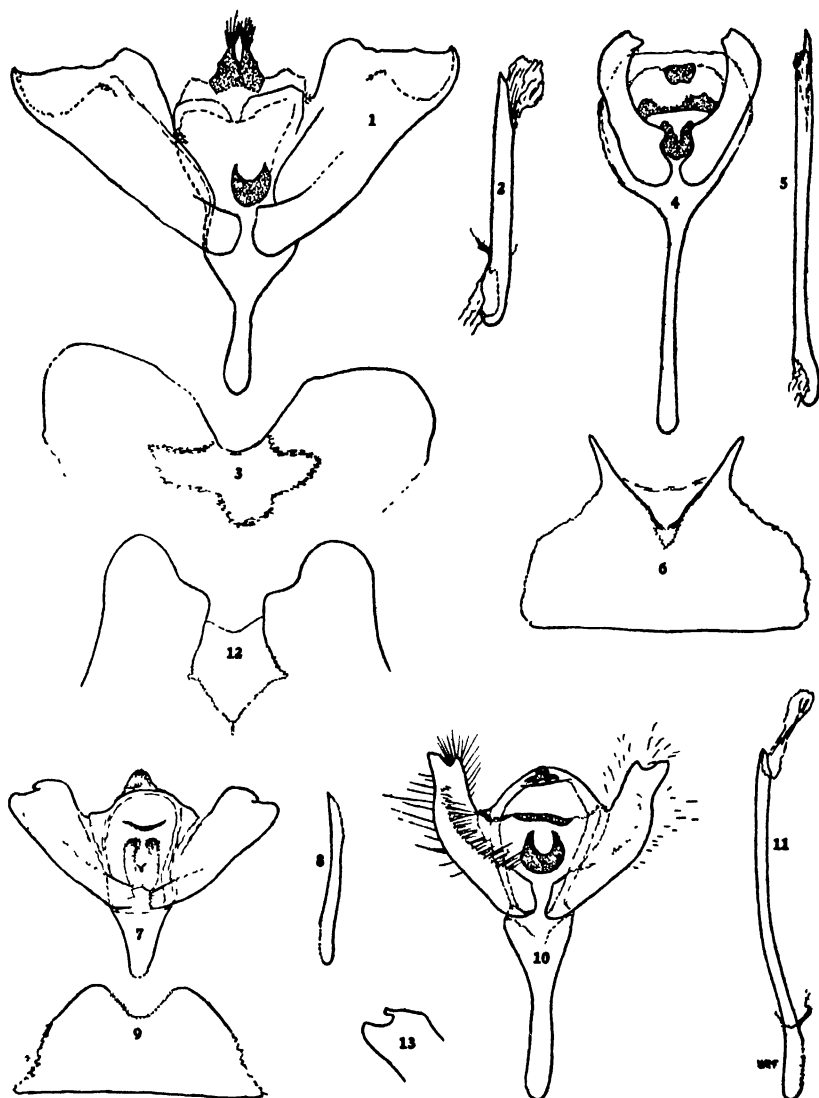
This may possibly be the female of *maxima*; it is equally large, and its structures show a similar position, intermediate between *confusa* and *grandior* on the whole; but the black pattern is much heavier, and this does not vary sexually in other species of the genus. The solid black costa of hind wing and deep bowl-shaped, symmetrical vaginal plate are unique.

Eneñas to Dos de Mayo, Camino del Pichis, Peru, alt. 2000 M., July 5, 1920 (Forbes), holotype in coll. Cornell University; paratype from Eneñas, July 4, both females.

***T. mystica* Zikan**

Figures 4, 5, 6, 17

To an amazing degree a doublet of *confusa*, in spite of differences of structure so great that d'Almeida would make a separate genus. They are identical in size, color and pattern, and even in having the same form with yellow hind wing over the main range and a pale race in Bolivia (Coroico and Rio Songo). So far as data can be trusted the ranges are also identical, for our record of *mystica* from Villavicencio, R. Meta, Colombia can be matched by the British Museum's *confusa* from "Llanos de la Rio Meta," and the National Museum has both taken from the vicinity of Santa Cruz, eastern Bolivia (not plotted on the map). Chapada, Matto Grosso (Nat. Mus., not plotted) and Jatahy, Goyaz (Brit. Mus.) are beyond our known records for *confusa*, but only the latter is a place where *themisto* would rather be expected. As with *confusa* the Bolivian pale race is not pure, our specimen from the Rio Songo being a little yellower than the *confusa* from the same place. Both species are also found on the Lower Amazon, but not farther east.



Figures 1-3. *Thyridia maxima*, new species, holotype. 1. Male genitalia opened from ventral side, with aedoeagus removed. Uncus and juxta stippled. 2. Aedoeagus. 3. Posterior portion of eighth tergite, unrolled. 4-6. *Thyridia mystica*, the transtilla is also stippled, and valves less expanded, to show ventral lobe. 7-9. *Thyridia themisto*, same structures as in figs. 1-3. 10-12. *Thyridia grandior*, new species, holotype; same structures as in figs. 1-3. 13. *Thyridia confusa*, apex of left valve.

All the drawings are made to the same scale with the projection microscope. Asymmetries are due to the copying of slight distortions of the mounts, the species being symmetrical.

The slightly bifid uncus was overlooked by Zikan (fig. 4). The female genitalia are unique in having a dense double tuft of setae on the vaginal plate behind the vaginal opening (fig. 17).

***Thyridia grandior* new species**

Figures 10, 11, 12, 16

Markings in general identical with *T. confusa* and *mystica*, the following differences being true at best on the average. Black pattern rather heavier, the bar across cell normally about 4 mm. thick and the one at end of cell 6 mm. thick down to lower angle of cell, then abruptly narrowing in the majority of specimens. First band running through to Sc as a rule (commonly stopping at R in *confusa* and *mystica*). Band of hind wing typically constricted below cell, but in Andean specimens of nearly even width. Under side with yellow postmedial scaling absent above vein M<sub>1</sub>, like most specimens of *mystica* and *nigerrima*, unlike *themisto*, *confusa*, and *maxima*. Female with a small white dash on lateral edge of tergite, representing the lateral yellow stripe, unlike the residue. Expanse 76–97 mm., typical and Peruvian specimens with average male 84 mm., female 90 mm., the Ecuador race ♂ 88 mm., ♀ 95 mm.

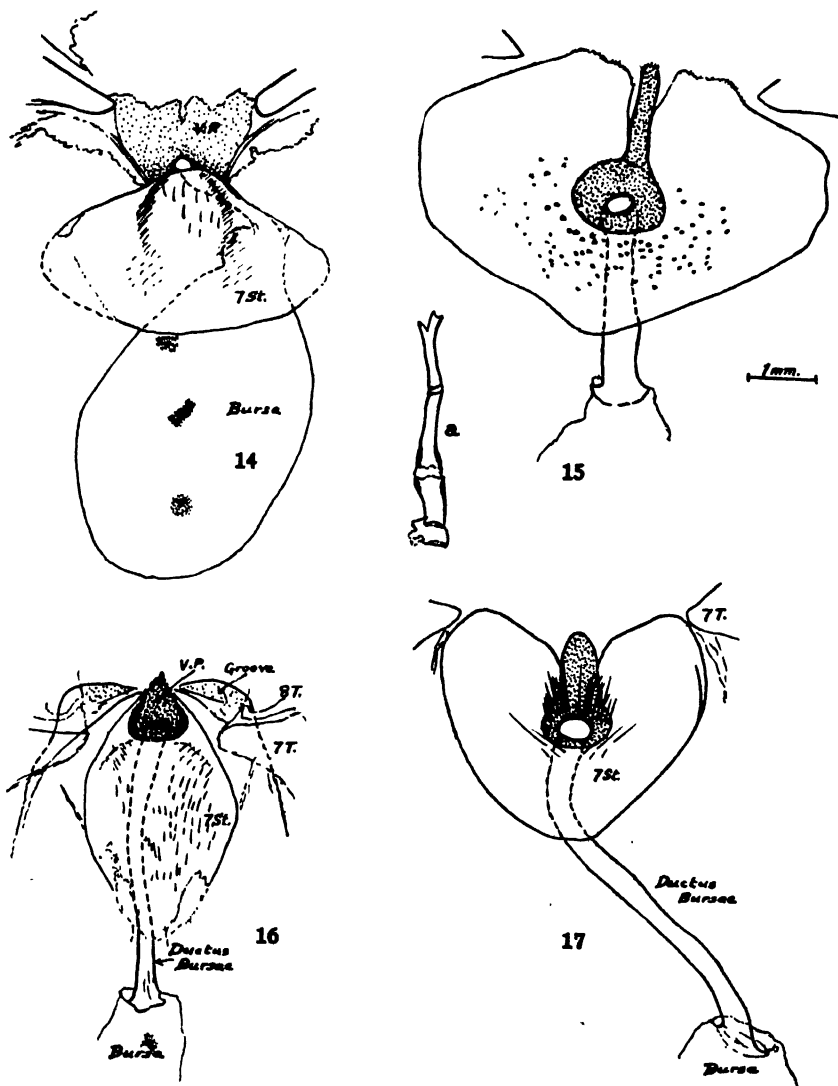
Male fore tibio-tarsus fluctuating in length from two-thirds as long as femur to rather longer, 1.2 to 1.8 mm. Hind wing with Sc and R approaching rather more closely than in *mystica*, correlating with the presence of the hair-pencil. Male genitalia (figs. 10–12) in resting position completely covered by the slightly lengthened last sternite below and two enormous lateral flaps of the last tergite above, the white patches on the latter lower on the side than in other species. Uncus small, knob-like, but a little more sclerotized than *confusa* and *mystica*, with a broadly expanded sclerotized base; valves bluntly bifid at tips, without the subbasal lobe of *mystica*, juxta fitting the aedoeagus more neatly than in *confusa* and *mystica*, saccus only two-thirds as long as in *mystica* and much stouter, but more than twice as long as in *themisto* and *confusa*. Aedoeagus as in *mystica*.

Female with a distinct hair-pencil. Vaginal plate (fig. 16) nearly round in superficial view, its front edge swollen and glossy, the posterior part sunken and continued laterally in a pair of transverse sclerotized grooves; 7th sternite densely scaled and bristled, elongate and convex, but without the overhanging knoblike structure of *confusa* and *themisto*.

On coloring there are three distinct races, but two of them intergrade, and will not be separately named at present.

A. *T. g. grandior*—Guiana and Amazon Basin to eastern Peru: St. Laurent, French Guiana, holotype and paratype ♂ in Cornell University collection; Mana, French Guiana, June, 1917, ♂ (Carnegie Museum); also three specimens from Mus. Comp. Zool. and one from Nat. Mus. without localities. This race is yellow, with hind wing much brighter than fore wing and transverse band of hind wing sharply constricted below cell.

B. Ground paler and more even yellow, transverse bands of fore wing narrower and the outer less constricted at lower end of cell; band of



Last sternites and vaginal plates of females. The four figures are drawn as projected, and at the same scale. Figure 14. *Thyridia confusa*. 15. *T. nigerrima*, holotype; a, spermatophore. 16. *T. grandior*. 17. *T. mystica*.



hind wing of even width. Eastern Andean Valleys of Peru, intergrading with the preceding. Paratypes: Balsapuerto, Rio Paranapura, Peru, June 1935, Klug (Reading Museum); Achinamiza, Peru, Oct. 24 (Reading Museum); Rio Santiago, Peru, Nov. 12, 1924, Bassler (Amer. Mus. Nat. Hist.); Rio Urubamba, Feb. 17, 1929, Bassler (Amer. Mus. Nat. Hist.); Upper Rio Napo Basin, Jan.-Feb. 1931, Bassler (Amer. Mus. Nat. Hist.); Upper Rio Marañon, Oct. 2, 1924, Bassler (Amer. Mus. Nat. Hist.); "Brazil," without authentic data and probably in error, pair, (Amer. Mus. Nat. Hist.). Also a pair from middle Rio Ucuyali, Peru, Jan. 21, 1927, Bassler, and a female from the Rio Alto Juruá, E. May (Amer. Mus. Nat. Hist.) transitional to the type race, with the light marking and even transverse band of hind wing of this race and the bright hind wing of the type.

**C. T. g. incana**, new race. Ground white with the faintest yellow tint, the hind wing more heavily scaled, but not yellower than fore wing; black pattern very heavy, the band at end of cell of fore wing of full width to lower angle of cell or even extended out in cell M<sub>1</sub>, and then abruptly narrowing; on hind wing strong and of even width.

Mountains of Ecuador only at higher altitudes, the labelled specimens from 1000 to 1700 M. Puyo, Rio Pastaza, Oriente, Nov. 7, 1926, E. E. Loch, male type and two paratypes (Amer. Mus. Nat. Hist.); Oriente, MacIntyre, (U. S. Nat. Mus.); Rio Topo, July 15, 1936 (Amer. Mus. Nat. Hist.); Hacienda la Mascota, 4500 ft., Rio Topo, Casey (U. S. Nat. Mus.); Macas, Oriente (U. S. Nat. Mus.); Rio Lluchin, Tungurahua, 1700 M., Sept. 1939, and Rio Arajuno, Oriente, April 30, 1941 (F. M. Brown); "Colombia" without authentic data (U. S. Nat. Mus.).

Riley also adds the following localities from the British Museum collections: yellow races Cayenne, French Guiana, Teffé and Cametá, Amazons, Rio Topo, Ecuador, Rio Huambo (so nearly as the label can be read), Chanchamayo, Chambirayacú, near Yurimaguas, and the R. Ucuyali, Peru; and notes the pale race also from Rio Topo, Ecuador. As a whole the distribution runs through the center of that for *confusa* and *mystica*, not being reported as yet from Bolivia or Goyaz, and not from any definite place in Colombia.

#### **T. singularis** Stgr.

The distinctive pale coloring may be associated with the arid country in which it is found; it was originally described from Bahia, but recent specimens come from Pernambuco. One in the Reading Museum, marked "Muzo, Colombia" is presumably mislabelled, but the specimen differs from the original figure and all other specimens I have seen by the white subdorsal spotting of the abdomen, as in the rest of the genus.

# ON THE SO-CALLED MISCHOCYTтарUS ATER, POLYBLA ATRA, AND THEIR RELATIVES

(Hymenoptera, Vespidae)

J. C. BEQUAERT,

Museum of Comparative Zoology,  
Cambridge, Mass.

Several closely related species of neotropical social wasps are homeo-chromic with the so-called *Polybia atra* de Saussure. Their differentiation is as yet far from clear and will be discussed in this paper. First, however, the involved nomenclature of *P. atra* and its homonym, *Mischocyttarus ater*, should be cleared up. The prevailing tangle is due mainly to a series of errors and subsequent corrections made by de Saussure in his Monograph of Social Wasps. As I believe current use of these names incorrect, all pertinent evidence is given in full and in chronological order. The years refer to the bibliographies in the taxonomic discussions of the several species.

1. *Vespa atra* Olivier, 1791.—“*Vespa atra*, alis nigris; petiolo companulato. Elle a environ six lignes de long [6 French lines=13.5 mm.]. Tout le corps est noir, luisant, sans taches. Les mandibules sont cornées, dentées, d'un brun ferrugineux luisant. Le pétiole n'est pas si long que dans les autres espèces et est un peu renflé à son extrémité. Les ailes sont noirâtres. Elle se trouve à Cayenne.” The type is lost. The description is very vague; but, in the Guianas, it seems to fit only the wasp called by Ducke and Zikan *Mischocyttarus ater* and at one time described by Ducke (1904) as *Megacanthopus imitator*. It should be noted, however, that Olivier does not mention the whitish tips of the wings characteristic of the most common form of this *Mischocyttarus*. Perhaps he had the form with uniformly blackish wings, which I described (1938) from Trinidad as *Mischocyttarus ater* var. *uniformis*.

In view of the uncertainty which will always attach to Olivier's name, it is fortunate that it must be discarded in any case as a homonym of the earlier *Vespa* (*Crabro*) *atra* Gmelin (1790, in Linnaeus, Syst. Nat., 13th ed., I, pt. 5, p. 2765). The case is not altered by the fact that Gmelin merely renamed *Crabro tricinctus* Fabricius (1775), itself a synonym of *Sphecius speciosus* (Drury, 1773), a sphecoïd wasp. As shown below, the earliest valid name for “*Mischocyttarus ater*” is *M. socialis* (de Saussure).

2. *Polistes ignobilis* Haliday, 1836.—“Coeruleus; alis obscure hyalinis costa fusca. Long. corp.  $5\frac{3}{4}$  lin. [ $5\frac{3}{4}$  English lines=12.1 mm.]. Alar. 11 lin. [=23.2 mm.; evidently spread of wings]. Fem. Obscure coeruleus. Clypei apex medio productus acuminatus. Mandibulae praelongae. Lacinae labii praelongae, apicibus pendulis, glandulosis. Segmentum primum infundibuliforme, subpetiolatum. St. Paul's [São Paulo, Brasil].” H. de Saussure saw the type at the Linnaean Society in London, where it may yet be preserved. At first (1854) he referred

it to the wasp which he described as "*Polybia atra*," and, I believe, correctly so. In the revised Explanation of Plate XXIV, published in 1858, he wrote, however: "Le *Polistes ignobilis* n'appartient pas à ce genre [*Polybia*], mais au genre *Montezumia*." This conclusion was certainly not reached after a new study of the type and is plainly erroneous. The acuminate apex of the clypeus is not found in any species of *Montezumia*, nor in any other South American solitary vespid with which I am acquainted. In the region of São Paulo there are only two social wasps agreeing with Haliday's description: the one described by de Saussure as "*Polybia atra*," and *Polybia tinctipennis* Fox. The first of these is by far the more common and, moreover, has a much shorter basal stalk to the first segment, fitting better Haliday's description. It also has a frosty pruinosity, sometimes giving a bluish sheen to the body (Haliday's "obscure coeruleus"), while *tinctipennis* is more velvety. I propose to adopt Haliday's name for de Saussure's "*Polybia atra*."

3. *Polybia atra* H. de Saussure, 1854 (description only; *not* the figure cited in the text).—"Nigra sericea; alis fuscis, marginibus hyalinis. ♀ Long. 11 mill.; env. 26 mill. ♂ Long. 12 mill.; env. 28 mill. *Ouvr.* Chaperon presque cordiforme, angulaire et arrondi au bas. Corselet rétréci en avant; métathorax arrondi; pétiole court, déprimé, en masse tronquée. Insecte d'un noir un peu argentin. Abdomen soyeux. Pattes noires. Ailes transparentes dans les bords, fortement enfumées à la base et le long de la côte; deuxième cubitale en trapèze, plus longue que large. *Mâle*.—Chaperon allongé, pentagone, terminé angulairement et portant de chaque côté une ligne argentée. Antennes un peu ferrugineuses en dessous; le premier article orné d'une ligne ferrugineuse ou jaune-pâle. *Rapp. et diff.* Très voisin de la *P. socialis*. Voyez la description de cette espèce. *Habite*: Le Brésil, les îles du Parana. Elles se trouvent en grande abondance, et construisent un nid en carton de forme pyramidale, qu'elles suspendent aux arbres.<sup>1</sup> Elles poursuivent avec acharnement ceux qui touchent à ces nids. Les rayons sont disposés à l'intérieur par couches horizontales, et sont percés d'un trou au milieu. (Musée de Paris). Rapportée par M. Alc. d'Orbigny qui la dit très commune." As recognized by Ducke, this description clearly refers to a *Polybia*, not to a *Mischocyttarus*, and is therefore not based on *Vespa atra* Olivier. De Saussure's name cannot be used, however, for two reasons: (1) it was not based on a new species in the genus *Polybia*, but was a definite misidentification of Olivier's *V. atra*; (2) the earlier name, *Vespa ignobilis* Haliday applies to the *Polybia* described by de Saussure.

In the text (p. 181), de Saussure refers under *P. atra* to Pl. XXIV, fig. 5, which does not show a *Polybia*, but Olivier's *Mischocyttarus ater* (= *socialis* de Saussure). As first issued in 1854,<sup>2</sup> this plate bore engraved the name "*P. ignobilis*" for fig. 5, while on the printed Explanation it was labelled "*Polybia atra* Oliv." Later, however, de Saussure

<sup>1</sup>This was probably not the true nest of *Polybia atra*, which, according to R. V. Ihering and Ducke, appears to be usually built in a cavity underground.

<sup>2</sup>According to F. J. Griffin (1939, Jl. Soc. Bibl. Nat. Hist., I, pt. 7, p. 212), pp. 145-192 of the text and Pl. XXIV were received together at the British Museum March 11, 1854.

recognized that his description (p. 181) and his fig. 5 referred to two different wasps. In 1858, he issued a new Explanation of Pl. XXIV (marked VV in one corner), with instructions to discard the earlier one (marked V in one corner).<sup>3</sup> In this, he now calls fig. 5 *Polybia socialis* Sauss., adding in a footnote: "La *Vespa atra* d'Olivier est évidemment ma *Polybia socialis* et non ma *Polybia atra*." He now also applies the name "*Polybia atra* Sauss." (not of Olivier) to his fig. 1 (which he had called *P. socialis* in 1854) and he proposes the new name *Polybia nigra* for this wasp.

4. *Polybia socialis* H. de Saussure, 1854 (description only; not the figure cited in the text).—"Nigra; mandibulis rufis alis nigris, apice albidis. ♀. Long. 9 mill.; env. 22 mill. *Ouvr.* Comme la *P. atra* dont elle ne diffère que par les caractères suivants: Mandibules plus courtes, rousses. Chaperon plus large en bas qu'en haut, tronqué droit à son bord antérieur. Corselet large en avant, finement rebordé. Méta-thorax un peu excavé au milieu. Pétiole plus cylindrique, peu élargi en arrière. Corps plus noir, ne portant pas de poils argentés. Ailes d'un brun presque noir, le bout seulement transparent. Habite: Le Brésil (Musée de Paris)." As later recognized by de Saussure (1858, in corrected Explanation of Plate XXIV), this description was based on the true *Vespa atra* Olivier, which is a *Mischocyttarus*. Since Olivier's name is antedated, as shown above, this wasp must be called *Mischocyttarus socialis* (de Saussure).

The text (p. 177) refers under *P. socialis* to Plate XXIV, fig. 1, which is labelled, both on the Plate (engraved) and in the first printed Explanation (issued in 1854): "*Polybia socialis*." But in the new Explanation of Pl. XXIV (issued in 1858), de Saussure corrects this to "*Polybia atra* Sauss." (not of Olivier), for which he proposed the new name *Polybia nigra*. On the other hand, he now correctly refers his fig. 5 to *Polybia socialis* de Saussure (as described in 1854).

Ducke (1910, p. 502) states that he saw de Saussure's types of "*atra*" and "*socialis*," and that those at the Paris Museum agree with the figures, while those at the Geneva Museum agree with the descriptions. In view of the fact that de Saussure himself corrected in print the erroneous captions of his figures, I accept his descriptions as defining his names. It is beyond doubt that his description of *P. socialis* was based on the *Mischocyttarus*, while that of *P. atra* was based on the *Polybia*.

5. *Polybia nigra* H. de Saussure, 1858.—As shown above, this was a new name proposed for "*Polybia atra* de Saussure," as described in 1854 (not of Olivier), and is in my opinion a synonym of *Polybia ignobilis* (Haliday, 1836). If it were shown, however, that Haliday's *Polistes ignobilis* was some other wasp, the name *Polybia nigra* will have to be used for this *Polybia*.

6. *Polybia decepta* Fox, 1895. "Entirely of a very dark, almost blackish brown, except the mandibles, which are ferruginous, and the antennae, which are black, clothed with a sericeous pile; wings: basal

<sup>3</sup>All copies I have seen of de Saussure's work contain either the one or the other of the two "Explanations" of Pl. XXIV. I have consulted both.

two-thirds of anteriors black, as are also the nervures, on the remainder whitish, the nervures yellowish, posteriors blackish throughout; middle-segment with a deep, convex depression, extending from base to apex; hind coxae very large; medial and hind tarsi with joints 3 and 4 greatly extended at apex within, particularly the fourth joint; petiole of abdomen robust, most convex in middle above, before the apex with a transverse impression. Length, 15 mm. One specimen, either a ♀ or ♂. Easily distinguished by the color of wings, which is exactly as in *Chartergus apicalis*, as in the rest of the insect. It evidently belongs to Saussure's Division *Iota*, and seems to come closest to *P. socialis* Sauss. from Brazil. Its similarity in color to *Chartergus apicalis* is really remarkable." No locality is mentioned, but the insect came from northwestern Mexico, either from San José del Cabo, Lower California, or from Tepic, Nayarit; most probably the latter. Mr. E. S. Ross informs me (May 14, 1942) that the unique type is at the California Academy of Sciences under No. 261. From the description, *P. decepta* is clearly either a synonym of *Mischocyttarus socialis* (de Saussure) (= *atra* Olivier), or a color form of that species. Possibly the blackish-brown, instead of black, color was accidental. I have seen several specimens of *M. socialis* from eastern Mexico (Cordobá, State of Vera Cruz), Guatemala (Mocá near Guatalon; Quirigua) and Costa Rica (Aserri); but these are all pure black, with the mandibles either black or ferruginous. Some specimens from Brasil, however, show a tendency toward brownish-black on head and thorax. The Mexican and Central American specimens are often larger than those from Brasil or Peru; but after repeated study I was unable to discover reliable structural differences to separate them from the Brazilian or typical form. Nevertheless, if a name were needed for these northern specimens, *decepta* Fox might be available.

7. *Megacanthopus imitator* Ducke, 1904.—"♀: *Chartergo fraterno* Grib. colore similimus, ater praecipue capite griseotomentoso, alis nigris, apice albis. Thorax subtiliter dense punctulatus et coriaceus, pronoto antice truncato, angulis lateralibus distinctissimis, sed rotundatis. Mesopleurae episterno et epimero per sutural parum distinctam obsolete separatis. Segmentum abdominale 1.<sup>um</sup> thorace multum brevius, segmento 2.<sup>o</sup> haud longius, supra fortissime convexum, apicem versus graduatim dilatatum hic vix duplo latius quam basi, lateraliter haud tuberculatum. Longitudo corporis 13–16 mm.—♂: ut ♀, sed antennis ad apicem incurvatis, articulo ultimo distinctissime attenuato. Na coloração absolutamente igual ao *Chartergus fraternus*, do qual se distingue facilmente alem dos caracteres genericos pelos ocelli postos num triangulo mais largo que alto, os angulos lateraes do pronotum mais proeminentes, porem mais arredondados, o thorax todo coriaceo e finissimamente pontuado, o mesonotum mais comprido, o segmento mediano muito mais obliquo, o abdomen em cima menos, porem em baixo mais piloso. Belem do Pará; Anajás (Ilha de Marajó), raro."

The nest was figured on pl. I, fig. 5, where the name "*Polybia imitatrix*" is used. As was recognized by Ducke himself, *M. imitator* is conspecific with *Mischocyttarus socialis* (de Saussure).

*Mischocyttarus imitator* Zikan, 1935, Arq. Inst. Biol. Veg., Rio de Janeiro, I, pt. 3, p. 180, figs. 42, 44, 45, 46 (nest on pl. I, fig. 1), is an

entirely different wasp. After seeing cotypes, kindly sent by Mr. Zikan, I am inclined to regard it as a color variant of *Mischocyttarus cassununga* (R. v. Ihering, 1903).

8. *Mischocyttarus ater* var. *uniformis* J. Bequaert 1938.—“♀. Agrees structurally in every respect with *M. ater* (Olivier), but differs in the colour of the wings. The apical third of the fore-wing is not milky-white as in the typical form of the species, but infuscated throughout, though slightly and gradually paler than the remainder of the wing. Trinidad, one ♀, holotype.” I have once more compared the type with Brazilian and more northern specimens of *M. socialis* and can find no additional differences. The mandibles and most of the scape are ferruginous. As pointed out above, Olivier may have described this form and not the more common one.

It will be seen that some of my conclusions differ from those reached by Ducke (1913, Deutsch. Ent. Zeitschr., p. 322; 1918, Rev. Mus. Paulista, X, pp. 335 and 351). He uses the specific name “*atra*” for both the *Polybia* and the *Mischocyttarus*, which is inadmissible under the rules. He also lists “*Polybia nigra* de Saussure” as a synonym of the *Mischocyttarus*, while it was explicitly based on de Saussure’s description of *Polybia atra* and his pl. XXIV, fig. 1.

### *Mischocyttarus socialis* (de Saussure, 1854)

#### 1. Typical Form

- Polybia socialis* de Saussure, 1854, Et. Fam. Vesp., II, p. 177 (♂; description only. *not* the figure cited in the text; Brasil); 1858, *Op. cit.*, revised printed Explanation of Pl. XXIV, fig. 5. F. Smith, 1857, Cat. Hym. Brit. Mus., V, p. 125-Fox, 1898, Proc. Ac. Nat. Sci. Phila., p. 450 (Rio de Janeiro. I have seen this specimen at the Carnegie Museum, Pittsburgh). W. A. Schulz, 1905, Hymenopteren-Studien, p. 129 (♀ ♂; Belem do Pará; “Bogotá, Colombia”).
- Polybia ignobilis* H. de Saussure, 1854, Et. Fam. Vesp., II, Pl. XXIV, fig. 5 (name engraved on Plate). *Not Polistes ignobilis* Haliday, 1836.
- Polybia atra* “Olivier” H. de Saussure, 1854, Et. Fam. Vesp. II, original printed Explanation of Pl. XXIV, fig. 5 (*not* the description on p. 181). Brêthes, 1903, An. Mus. Nac. Buenos Aires, IX, p. 29. R. v. Ihering, 1904, Rev. Mus. Paulista, VI, p. 190, fig. 2 (on p. 189), p. 255, Pl. VII, fig. 15 (Ypiranga, S. Paulo; Rio Grande do Sul; nest). *Not Vespa atra* Olivier, 1791.
- Megacanthopus ater*, Ducke, 1905, Bol. Mus. Goeldi, IV, p. 689 (Brasil: São Paulo; Pará; Oyapoc.—Guianas); 1906, Revue d’Entom., XXV, p. 10 (♀; Rio de Janeiro); 1907, Zeitschr. Syst. Hym. Dipt., VII, p. 139; 1907, Bol. Mus. Goeldi, V, pp. 185 and 190. Salt, 1931, Proc. Ent. Soc. London, VI, p. 21 (Colombia: Rio Frio).
- Mischocyttarus ater*, Ducke, 1918, Rev. Mus. Paulista, X, pp. 351 and 369 (specimens seen: Brasil: State of Pará: Ilha de Marajó. Goyaz. São Paulo: Ypiranga; Piquete; Jundiáhy.—Peru: Iquitos.—Venezuela.—Costa Rica). A. de Winkelried Berton, 1918, An. Cientif. Paraguayos, (2) No. 3, p. 204 (Paraguay: Puerto Berton). da Fonseca, 1926, Rev. Mus. Paulista, XIV, p. 175. Zikan, 1935, Arq. Inst. Biol. Veg., Rio de Janeiro, I, pt. 3, p. 155, figs. 78 and 83; Pl. II, fig. 2; Pl. III, figs. 5-6. J. Bequaert, 1937, Bull. Brooklyn Ent. Soc., XXXII, p. 116 (introduced with bananas in United States). Rau, 1940, Ann. Ent. Soc. America, XXXIII, p. 90 (Mexico: Córdoba, Vera Cruz).
- Polybia decepta* Fox, 1895, Proc. California Ac. Sci., (2) V, p. 269 (♀ or ♂. Mexico: either San José del Cabo, Lower California; or Tepic, Nayarit).
- Megacanthopus imitator* Ducke, 1904, Bol. Mus. Goeldi, IV, pp. 359 and 362 (♀ ♂. Brasil: Belem do Pará; Anajás, Ilha de Marajó; type locality not selected). Ducke, 1905, Revue d’Entom., XXIV, p. 21.

*Specimens Examined*.—MEXICO: Córdoba, Est. Vera Cruz. GUATEMALA: Quiriguá; Olas de Mocá, Dept. Solola. COSTA RICA: Mt. Redondo; Aserri. COLOMBIA: Medellín, Dept. Antioquia; Sasaima, Dept. Cundinamarca; Aracataca, Dept. Magdalena; Restrepo, Int. Metá. PERU: San Ramon, Valle Chanchamayo. BRASIL: St. Amaro, Est. do Rio; Itatiaia, Est. do Rio; Puerto Velho, Rio Madeira; El Dorado, São Paulo. Specimens were taken at Madison, Wisconsin, from a bunch of imported bananas; and others were intercepted at Mobile, Alabama, in bananas freshly arrived from Nicaragua. The supposed occurrence at Bogotá, Colombia, is based on erroneous labelling of specimens.

## 2. *M. socialis* var. *uniformis* J. Bequaert, 1938

*Mischocyttarus ater* var. *uniformis* J. Bequaert, 1938, Proc. Ent. Soc. London, Ser. B, VII, p. 134 (♀; Island of Trinidad).  
? *Vespa atra* Olivier, 1791, Encyclop. Méthod., Insectes, VI, p. 674 (Cayenne, French Guiana). Not *Vespa atra* Gmelin, 1790.

Known thus far with certainty from the type specimen only; but Olivier's *Vespa atra*, from French Guiana, appears to have been based on this form, not on typical *M. socialis*.

## *Polybia* Lepeletier

Five neotropical species of *Polybia*, separable on structural characters, are superficially alike in size and color. They measure 12 to 14 mm. in total length, the fore wing 8.5 to 10 mm. The body is black (rarely somewhat brownish), except sometimes for reddish or rufous areas on mandibles and legs, often whitish spots on the base of the mandibles and sides of clypeus, and very rarely traces of whitish-yellow at the hind margin of the pronotum or of some of the tergites. The thorax, particularly on the sides, is not or slightly silky. The wings are wholly or mostly infusate, sometimes clearer posteriorly or toward the tips, or the costal and radial cells are conspicuously darker. The eyes are distinctly, but sparsely hairy. The following key will separate the queens and workers of these species.

1. First abdominal tergite distinctly punctate. Mesopleura and propodeum with large punctures. Body somewhat velvety. Stalk-like base of first tergite one-third to half the total length of the segment. . . . . 2  
First abdominal tergite impunctate. Punctures of mesopleura and propodeum medium-sized or very small. Body not velvety. . . . . 3
2. Oculo-malar space at its shortest over half the length of the tenth antennal segment. Concavity of propodeum narrow, groove-like, but very weak or barely indicated in upper third. Clypeus slightly wider than high, *tinctipennis*  
Oculo-malar space at its shortest less than half the length of the tenth antennal segment. Concavity of propodeum well developed over entire length, broader and more shallow. Clypeus slightly wider than high, *rufitarsis*
3. Oculo-malar space at its shortest about half the length of the tenth antennal segment. Clypeus about as high as wide. Propodeum with the median groove broad and very shallow, the sides irregularly and finely rugulose. First tergite gradually swollen over posterior two-thirds (in profile or from above). . . . . *ignobilis*  
Oculo-malar space very short, the mandibular condyle nearly touching the eye. Sides of propodeum without traces of irregular rugosities. . . . . 4

4. First tergite wide and rather abruptly swollen over posterior two-thirds (in profile or from above). Propodeum shallowly and broadly concave. Clypeus slightly wider than high. . . . . **simillima**  
 First tergite more slender, gradually swollen over posterior half (in profile or from above). Propodeum with a distinct groove-like depression. Clypeus about as high as wide. . . . . **raui**

### ***Polybia ignobilis* (Haliday, 1836)**

Figure 1 D-F

*Polistes ignobilis* Haliday, 1836, Trans. Linn. Soc. London, XVII, p. 322 (♀. São Paulo, Brasil).

*Polybia socialis* H. de Saussure, 1854, Et. Fam. Vesp., II, Pl. XXIV, fig. 1 (name engraved on Plate and in printed original Explanation; *not* the description on p. 177). R. du Buysson, 1910, Zool. Jahrb., Abt. Syst., XXIX, pp. 232 and 239 (Paraguay: Asuncion; Trinidad; Villa Morra; Tembetary; C. Olympe; Sapucay; San Bernardino.—Argentina: Chaco de Santa Fé; Salta.—Guianas.—Venezuela.—Colombia.—Panama: Darien.—The locality "Chile" is certainly erroneous. Alta Vera Paz, Guatemala, probably refers to a related species). Duce, 1910, Rev. d'Entom., XXVIII, p. 119.

*Polybia atra*, H. de Saussure, 1854, Et. Fam. Vesp., II, p. 181 (♀ ♂; description only, *not* the figure cited in the text. Islands in the Parana River, southern Brasil); 1858, *op. cit.*, II, corrected Explanation of Pl. XXIV, fig. 1. F. Smith, 1857, Cat. Hym. Brit. Mus., V, p. 126. Fox, 1898, Proc. Ac. Nat. Sci. Philadelphia, p. 450 (Brasil: Chapada; Santarem; I have seen these specimens at the Carnegie Museum, Pittsburgh). Kreichbaumer, 1900, Berlin. Ent. Zeitschr., XLV, p. 98 (Colombia: Santander; Rio Lebrija). Schulz, 1904, Berlin. Ent. Zeitschr., XLVIII, (1903), p. 257; Sitzungsber. Bayer. Ak. Wiss., XXIII, (1903), p. 792 (Brasil: Santarem). Duce, 1904, Bol. Mus. Goeldi, IV, pp. 344 and 351 (♀; Brasil: Santarem; Alemquer). Duce, 1910, Ann. Mus. Nac. Hungarici, VIII, pp. 493 and 502 (♀ ♂. Brasil: Montealegre.—Colombia: "Bogotá."—Venezuela: Caracas); 1913, Deutsch. Ent. Zeitschr., p. 331; 1918, Rev. Mus. Paulista, X, pp. 335 and 367 (specimens seen: Bolovia.—Argentina: Córdoba.—Brasil: Goyaz. Espirito Santo. Minas Geraes: Irara. São Paulo: Ypiranga: Jundiáhy; Campos do Jordão; Franca; Itatiba; Itapura; Barretos. Rio Grande do Sul). A. de Winkelried Bertonio, 1918, An. Cientif. Paraguayo, (2) No. 3, p. 204 (Paraguay). Brèthes, 1920, Ann. Soc. Ent. France, LXXXVIII, (1919), p. 391 (Argentina: San Ignacio, Misiones; Santiago del Estero). da Fonseca, 1926, Rev. Mus. Paulista, XIV, p. 173 (Brasil: São Paulo: Ypiranga). Hase, 1936, Sitzungsber. Ges. Naturf. Fr. Berlin, pp. 1-51, figs. 3, 6, 8, 13 (Venezuela: Ocumare La Costa). Sauer, 1938, Arq. Inst. Biol. São Paulo, IX, p. 189.

*Polybia nigra* H. de Saussure, 1858, Et. Fam. Vesp., II, in corrected Explanation of Pl. XXIV, for fig. 1, to replace "*Polybia atra* Sauss." Brèthes, 1903, An. Mus. Nac. Buenos Aires, IX, p. 31 (Argentina: Misiones; Paraná; Córdoba; Tucuman; Salta). Schrottky, 1903, An. Soc. Cientif. Argentina, LV, p. 179 (Argentina: Buenos Aires). R. v. Ihering, 1904, Rev. Mus. Paulista, VI, pp. 188 and 252, fig. 4 (on p. 189), (♀ ♂ Brasil: São Paulo: Ypiranga; Jundiáhy; Franca. Espirito Santo. Rio Grande do Sul. Minas Geraes.—Argentina: Córdoba.—Bolivia. Nest). Duce, 1905, Bol. Mus. Goeldi, IV, p. 678; 1905, Revue d'Entom., XXIV, p. 19; 1906, *op. cit.*, XXV, p. 8 (Brasil: Rio de Janeiro: Barbacena). Zavattari, 1906, Boll. Mus. Zool. Anat. Comp. Torino, XXI, No. 529, p. 12 (♀. Ecuador: Vinces; San José). Duce, 1907, Bol. Mus. Goeldi, V, p. 170; 1907, Revue d'Entom., XXVI, p. 94 (Brasil: Maranhão: Codo; Caxias; Parnahyba); 1908, *op. cit.*, XXVII, p. 85 (Brasil: Ceará; Baturité; Serra de Baturité; Quixadá; Humayta). Schrottky, 1909, Zeitschr. Wiss. Insektenbiol., V, p. 212. J. Bequaert, 1933, in Rau, Jungle Bees and Wasps of Barro Colorado Island, p. 311, fig. 1E. Martorell, 1939, Jl. Agric. Univ. Puerto Rico, XXIII, p. 230 (Venezuela: La Providencia; Turmero; Maracay; Caracas). Martorell and Salas, 1939, *op. cit.*, XXIII, p. 251 (Venezuela: Carapito; Maturin; common at flowers of *Borreria verticillata*).



*Specimens Examined*.—PANAMA: Barro Colorado Id., C. Z. COLOMBIA: Cartagena, Dept. Bolivar; Puerto Colombia, Dept. Atlantico; Sevillano, Dept. Magdalena; Rio Frio, Dept. Magdalena; La Cumbre; Cali, Dept. Valle; Cienaga, Dept. Magdalena; Medellin, Dept. Antioquia; Villeta, Dept. Cundinamarca; Aguadita, Dept. Cundinamarca; Sasaima, Dept. Cundinamarca; Restrepo, Int. Metá; Villavicencio, Inta Metá. VENEZUELA: Carapito; Caño Macarico, Orinoco Delta; San Pablo de Mendoza, Trujillo; Macuto; Ciudad Bolivar; Maturin; La Guaira; Ocumare La Costa; Guanta; Miranda (between Caracas and El Sombrero); Caracas; Valera; Antimano, at flowers of *Euphorbia caracasana*; Corazo Prado; Calabozo. BRITISH GUIANA: Mt. Roraima. BRASIL: Pernambuco; Cotinga Uruicuera, Amazonas; Santarem; Natal; Independencia, Parahyba; Rio de Janeiro; Conceição do Araguaia, Est. Pará; Itatiaya, Est. Rio; Cordisburgo, Minas Geraes; Serra do Cipo, Minas Geraes; Calado-Rio Doce, Minas Geraes; Anapolis, Goyaz; Corumba, Matto Grosso; Maracajú, Matto Grosso; St. Amaro, Est. Rio; Chapada; São Paulo (Capital); Campinas, São Paulo; Ypiranga, São Paulo; Eug. Lefèvre, São Paulo; Nova Teutonia, Sa. Catharina. PARAGUAY: Villarrica; Sapucay; Molinascue; Mbovevo; Puerto Bertoni; San Bernardino; Tacuru-Pucu. BOLIVIA: Canamina; Ivon, Rio Beni; Riberalta; Tumupasa; Rurrenabaque, Rio Beni; Espia, Rio Bopi; Ixiamas; Cochabamba, 2500 m. PERU: Chiclero; Combo. ARGENTINA: Tucuman; between Corrientes and Bella Vista; Córdoba; Bella Vista.

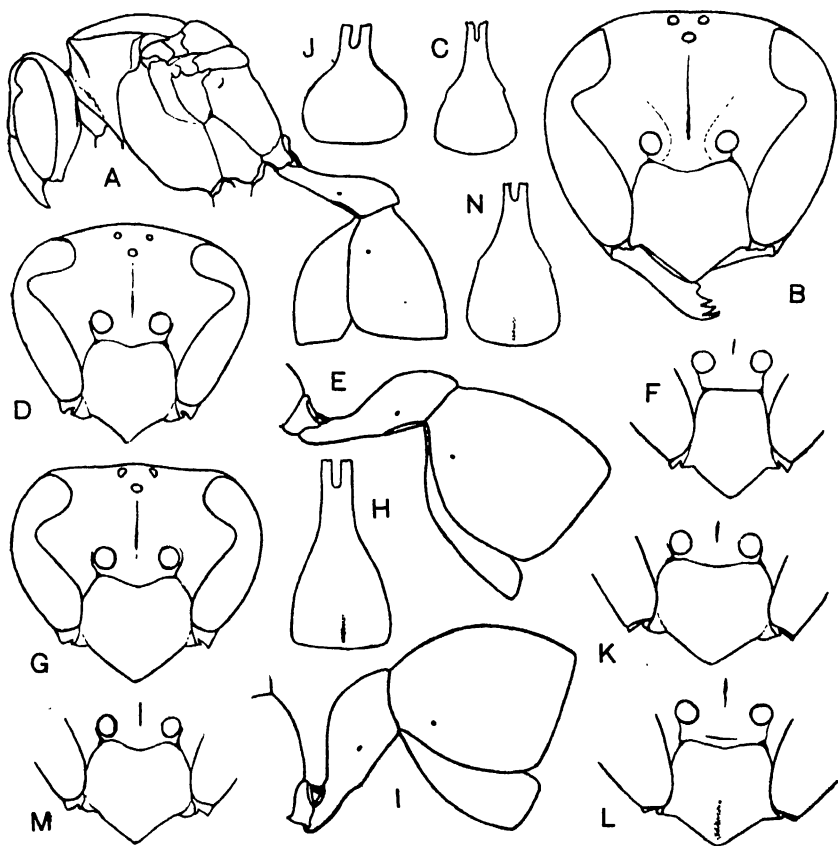
*P. ignobilis* occurs over most of South America, from Panama to northern Argentina; but in Brasil, as pointed out by Ducke, it prefers savanna country and rather avoids tropical rain forest. It does not ascend much above 6000 ft. and is lacking in the Andean region. Published records of its occurrence at or near Bogotá are based on wrong labelling of specimens taken in lower country some distance away, but shipped to Europe from the Capital. No social wasp is known to occur within the present boundaries of Chile. All supposed "*P. atra*" I have seen from north of Panama were either *P. simillima* or *P. rauli*, so that du Buysson's record from Alta Vera Paz, Guatemala, was almost certainly erroneous.

To judge from some 500 specimens studied, the color is remarkably constant over the vast area covered by the species. Often it is completely black; sometimes there is a narrow whitish line on each side at the apex of tergite 1, either short or long, but never meeting its fellow. The body bears a frosty pruinosity, which may impart to the abdomen a somewhat bluish sheen (as mentioned in Haliday's description). Thorax and tergite 1 have short, sparse, erect hairs. The costal cell and base of fore wing are conspicuously blackish, but the radial cell is mostly or entirely clear.

The male, first described by de Saussure (1854, as *P. atra*), differs from the female mainly in the usual sexual characters. The oculo-malar space is a trifle shorter and the outer orbit narrower, barely over one-third the width of the eye in profile. The clypeus is much narrower, distinctly higher than its greatest width, with a slight longitudinal depression over apical half. The segments of the flagellum are swollen,

giving it a "beaded" appearance. The following markings are ivory-white: a median pair of spots on frons (between antennal sockets and clypeus); under side of scape (in part or wholly); middle of hind margin of pronotum; a streak in upper corner of mesepisternum (below wing base); lateral crests of scutellum; sometimes a pair of dots or streaks in lower part of propodeum; and narrow apical margin of first tergite (complete or interrupted).

The thorax of *P. ignobilis* is narrower and more elongate than that of *P. simillima*, the mesonotum somewhat wider than long, the promesonotal suture semi-elliptical.



A-C, *Polybia rauli* J. Bequaert, female: A, body in profile; B, head in front view; C, first tergite from above. D-F, *Polybia ignobilis* (Haliday): D, head of female in front view; E, base of abdomen in profile; F, clypeus of male. G-H, *Polybia tinclipennis* Fox, female paratype: G, head in front view; H, first tergite from above. I-L, *Polybia simillima* F. Smith: I, base of abdomen in profile; J, first tergite from above; K, clypeus of female; L, clypeus of male. M-N, *Polybia rufularis* var. *peruviana* J. Bequaert, female holotype: M, clypeus; N, first tergite from above.

***Polybia simillima* F. Smith, 1862**

Figure 1 I-L

*Polybia simillima* F. Smith, 1862, Trans. Ent. Soc. London, (3) I, p. 39 (♀; Panama). Dalla Torre, 1894, Cat. Hym., IX, p. 166; 1904, Gen. Insect., Vesp., p. 78. Ducke, 1910, Ann. Mus. Nat. Hungarici, VIII, pp. 493 and 501 (♀ ♂. Mexico: Córdoba.—Colombia: "Bogotá"; middle Rio Magdalena). Rau, 1933, Jungle Bees and Wasps of Barro Colorado Island, pp. 46, 81-87, 130 (Barro Colorado Id., Panama). J. Bequaert, 1933, in Rau, *op. cit.*, p. 311, figs. 1F-G.

*Specimens Examined*.—MEXICO: Tuxtepec, Oaxaca. GUATEMALA: Cayuga. REPUBLIC OF HONDURAS: Prieta; Puerto Castilla; Portilla Grande; Tegucigalpa. PANAMA: Rio Pequeni; Pecora; Barro Colorado Id.; Las Sabanas; El Cermena; Caño Saddle, Gatun Lake; Ancon; La Campaña; Rio Trinidad; Juan Mina, Rio Chagres; Quipo; Changuinola District, Bocas del Toro. COLOMBIA: Rio Frio, Dept. Magdalena; Vista Nieve, San Lorenzo Mts., Dept. Magdalena; Muzo, Dept. Boyacá; San Vicente de Chucuri, Dept. Santander.

*P. simillima* occurs from southern Mexico to Colombia.

Some 150 specimens seen are all colored alike. The female and worker are black, usually with only a small ivory-white spot at the base of each mandible. In the female from El Cermeno, Panama, the post-scutellum has a medially interrupted, ivory-white anterior margin (not present in 8 other specimens from the same locality); some other specimens show traces of this. The darker costal area of the fore wing fills the entire radial cell.

*P. simillima* averages larger than *P. ignobilis*. The thorax is much shorter and stubbier and more truncate at the humeral margin; the mesonotum is about as wide as long, with the pro-mesonotal suture semi-circular. The head seen in front is wider than high. There is almost no erect pubescence, except on the propodeum, and the body is dull, owing to a microscopic alutaceous sculpture.

The male, briefly mentioned by Ducke (1910), is similar to the worker and female; but the clypeus is narrower, about as high as wide, with a distinct longitudinal depression over apical half, and covered with silvery pubescence. Outer orbits very narrow and not swollen at upper corners, barely over one-fourth the width of the eye in profile. Segments of flagellum not appreciably swollen. Black; mandibles without basal spots; only a pair of blotches on frons (below the antennal sockets) and under side of scape ivory-white.

Ducke synonymized *Polybia theresiana* W. A. Schulz (1904, Berlin. Ent. Zeitschr., XLVIII, p. 257; ♀ or ♂; between Bodega and Honda on the Rio Magdalena, Colombia) with *P. simillima*, but he evidently did not see the type and I am convinced that he was mistaken. The description does not agree, particularly with regard to the color. Schulz says there are ivory-white markings not only on the base of the mandibles, but also on the sides of the clypeus, the middle of the humeral margin, the apex of the first tergite and the hind margins of the second to fifth sternites (his third tergite is what is customarily called the second). I suspect that *P. theresiana* is a synonym or color form of *Polybia bifasciata* de Saussure.

***Polybia rauli* J. Bequaert, 1933**

Figure 1 A-C

*Polybia rauli* J. Bequaert, 1933, in Rau, Jungle Bees and Wasps of Barro Colorado Island, p. 309, figs. 1A-D (♀ ♂. Panama: Barro Colorado Island, C. Z. [type locality].—Guatemala: Cayuga). Rau, 1933, *op. cit.*, pp. 46 and 79-81.

*Specimens Examined*.—MEXICO: Cordobá, Vera Cruz. GUATEMALA: Cayuga (paratype); Sa. Emilia near Pochuta, 1000 m., Dept. Chimaltenango. PANAMA: Barro Colorado Id., C. Z. (types); Pecora; Paraiso; Alhajuelo. COLOMBIA: Muzo, Dept. Boyacá; Sabanetas near Barbarena.

*P. rauli* often occurs together with *P. simillima* and has the same distribution.

The thorax is slightly more slender than in *P. simillima*, the sides of the pronotum (as seen from above) being narrowed; but the pro-mesonotal suture is semi-circular. The body is somewhat shiny, the alutaceous microscopic sculpture of *P. simillima* being replaced by an extremely minute puncturation, in which larger punctures are scattered. It bears many short, erect, grayish hairs. There are usually small whitish spots on the base of the mandibles and at the sides of the clypeus, and traces of a whitish hind margin in the middle of the pronotum. The darker costal area fills the entire radial cell. The male is as yet unknown. Over 100 specimens were studied. *P. rauli* is slightly smaller than its near relatives.

***Polybia tinctipennis* Fox, 1898**

Figure 1 G-H

*Polybia tinctipennis* Fox, 1898, Proc. Ac. Nat. Sci. Philadelphia, p. 452 (♀ or ♂. Brasil: Chapada, Matto Grosso). Dalla Torre, 1904, Gen. Ins., Vesp., p. 78. Ducke, 1904, Bol. Mus. Goeldi, IV, pp. 344 and 352 (♀; Brasil: Itaituba on Rio Tapajoz); 1905, *op. cit.*, IV, p. 678 (Brasil: Obidos); 1905, Revue d'Entom., XXIV, p. 19; 1907, Bol. Mus. Goeldi, V, p. 170; 1910, Ann. Mus. Nat. Hungarici, VIII, pp. 493 and 502 (♀. Brasil: Est. Pará: Obidos; Belem. Amazonas: Santo Antonio do Iça. Minas Geraes: Barbacena. São Paulo: Ypiranga); 1918, Rev. Mus. Paulista, X, p. 335.

*Polybia ypiranguensis* R. v. Ihering, 1904, Rev. Mus. Paulista, VI, pp. 170 and 188 (♀ or ♂. Brasil: São Paulo: Ypiranga); 1904, Bull. Soc. Ent. France, p. 86 (♀).

I have seen the types of *tinctipennis* at the Carnegie Museum, as well as four paratypes of *ypiranguensis*. Ducke correctly synonymized these two names.

*Specimens Examined*.—REPUBLIC OF HONDURAS: Subirana. PANAMA: Paraiso. BRASIL: Chapada, Matto Grosso; western border of Matto Grosso; Ypiranga, São Paulo. PERU: San Ramon, Valle Chanchamayo, 800 m.

In the female of *P. tinctipennis*, the first abdominal tergite seen from above is longer and narrower than in *P. rufitarsis*, the stalk-like base being about as long as the apical widened portion, into which it passes more gradually; while, in profile, the swollen portion is more convex. The outer orbits are swollen and produced backward in the upper third; their edge with the occiput is rounded off, except over part of the middle third, where there is a short, fine but sharp carina. The punctures of the clypeus are as large as those of the mesopleura. The male is unknown.

Some 25 specimens seen are black, without pale markings on head and thorax, except for the faintly discolored hind margin of the pronotum; the apex of the first tergite is often obscurely whitish on the sides and the fifth tergite usually bears an apical whitish fascia which does not reach the sides and is notched or interrupted in the middle. This white apical margin of the fifth tergite is present in Fox' types, although it is not mentioned in the original description. More rarely the fourth tergite bears a similar fascia.

In typical *tinctipennis*, the fore wing is infusate over the basal two-thirds, somewhat more so in the costal cell; while the apical third (including part or most of the radial cell) is much clearer, either subhyaline or whitish-yellow, the veins of the pale area and stigma being russet or dirty yellowish. This is true of *ypiranguensis* also, as shown by the paratypes and by the author's statement that the wing is yellowish in the region of the stigma and of the second and third cubital cells. Typical *tinctipennis* is homeochromic with the typical form of *Mischocyttarus socialis*.

***P. tinctipennis* var. (or subsp.) *nebulosa*, new**

*Female and Worker*.—Differing from typical *tinctipennis* in the color of the wings, which are infuscated throughout, being only slightly and very gradually clearer apically; veins and stigma blackish-brown. Whitish apical margin of fifth tergite as in typical form.

*Specimens Examined*.—TRINIDAD: Holotype female (D. Vesey-FitzGerald). BRITISH GUIANA: Kamakusa, two female paratypes (H. Lang); Kartabo (W. Beebe); source of the Essequibo River (J. Ogilvie). Holotype and paratypes at Mus. Comp. Zool., Cambridge, Mass.; paratype at Am. Mus. Nat. Hist., New York.

This color form is homeochromic with *Mischocyttarus socialis* var. *uniformis*, which also occurs in Trinidad.

The specimens from Obidos, Brasil, which Ducke listed in 1905 under *P. tinctipennis*, appear to have been of the var. *nebulosa*, as they were said to lack all yellowish on the wings.

***Polybia rufitarsis* Ducke, 1904**

*Polybia rufitarsis* Ducke, 1904, Bol. Mus. Goeldi, IV, pp. 344 and 351 (♀; Itaituba on Rio Tapajoz, Brasil); 1905, *op. cit.*, IV, p. 678 (♀. Brasil: Est. Pará: Obidos; Otapoc. Amazonas: Lower Japura; Tefé; Tabatinga); 1905, *Revue d'Entom.*, XXIV, p. 19; 1907, Bol. Mus. Goeldi, V, pp. 170 and 180; 1910, Am. Mus. Nat. Hungarici, VIII, pp. 493 and 502 (♀. Brasil: Amazonas: Upper Trombetas; Faro; Santo Antonio do Iça; Lower Javary); 1918, *Rev. Mus. Paulista*, X, p. 334 (Brasil: Est. Amazonas: Rio Juruá.—Peru: Marcapata). da Fonseca, 1926, *op. cit.*, XIV, p. 173.

The original description was as follows: "♀. Nigra, fuscescenti-velutina, alis valde infuscatis, anticis costa nigra subcyanescenti-micante, harum apice albidis; tarsi omnibus rufis. Clypeus longitudine lator, nitidus, sparsim punctatus, margine apicali medico triangulariter producto. Genae sat angustae. Caput, thorax et segmentum abdominale 1.<sup>um</sup> sat dense et fortiter punctata, pronoto sine angulis, margine antico utrinque tenuiter carinulato, medio inermi, mesopleuris episterno et epimero haud separatis, segmento mediano postice sat late excavato,

segmento abdominali 1.<sup>o</sup> sat depresso, brevi, segmenti mediani linea mediana longitudinali haud longiore, campanulato, segmento dorsali 2.<sup>o</sup> valde dilatato, segmentis 2.<sup>o</sup>-6.<sup>o</sup> simul sumptis cordiformibus. Longitudo corporis 12 mm." This description was based on a single female. I have seen only one specimen that agrees with it, so far as color is concerned, in having all the tarsi russet or somewhat orange. It is a female from Moroballi Creek, Essequibo River, British Guiana, sent by Dr. O. W. Richards. In his later papers Ducke referred also to *rufitarsis* specimens with black tarsi, but I believe these should be separated as a distinct color form.

Structurally *P. rufitarsis* differs also from *P. tinctipennis* as follows: The first abdominal segment seen from above is shorter and wider, the stalk-like base being shorter than the apical portion, which is rather abruptly widened; while, in profile, the wider portion is more flattened. The outer orbits are swollen and produced backward in the upper third, but their edge with the occiput is blunt throughout, without or with a mere trace of a carina. The punctures of the clypeus are smaller than those of the mesopleura. The male is as yet unknown.

In the one typical *rufitarsis* seen, the clypeus is black with a diffuse brownish-orange spot on each side of the clypeus, the first tergite bears a short yellowish apical line on the sides, and the sixth tergite is partly yellowish-white; the second sternite bears brownish lateral spots. The wings are infusate, with the costal and radial cells darker, though not sharply set off.

***P. rufitarsis* var. (or subsp.) *peruviana*, new**

Figure 1 M-N

*Female or Worker*.—Black, including the entire legs of all pairs. Clypeus with a diffuse brownish-yellow spot on each side. Hind margin of pronotum medially and extreme apical sides of first tergite with traces of white; sixth tergite and second sternite black. Wings as in typical *rufitarsis*, infusate throughout.

*Specimens Examined*.—PERU: Valle Chanchamayo, 1100 m., female holotype and paratypes; San Ramon, Valle Chanchamayo, 800 m., female paratypes; Oxapampa, 1300 m., female paratypes; Tingo Maria, Rio Huallaga, 700 m., female paratypes; Satipo, east of Huan-cayo, 600 m., female paratypes (all collected by W. Weyrauch); El Campamiento, Col. Perene, female paratypes (J. C. Bradley). ECUADOR: Baños, Tungurahua, 1000 to 1500 m., female paratype (W. Clarke-Macintyre). BOLIVIA: Ivon, Rio Beni, female paratype; Tumupasa, female paratype (both collected by W. M. Mann). Holotype and paratypes at Mus. Comp. Zool., Cambridge, Mass.; paratypes also at U. S. National Museum, American Museum of Natural History, Academy of Natural Sciences of Philadelphia, and Cornell University.

This wasp appears to be common in eastern Peru. Evidently the specimens with black tarsi later included by Ducke under *rufitarsis* were of the var. *peruviana*. Unfortunately he does not separate their localities from the others.

# QUANTITATIVE ANALYSES ON THE CELLULOSE FERMENTATION BY TERMITE PROTOZOA<sup>1</sup>

R. E. HUNGATE,  
The University of Texas,  
Austin, Texas

Termites of the genus *Zootermopsis* have been used in many of the studies of cellulose digestion in the Isoptera. These termites are large, easy to handle, and abundant. The two species which have been used, *nevadensis* and *angusticollis*, are similar in habits and appearance but can be distinguished in most cases on the basis of the characteristics described by Sumner (1933). They show an overlapping distribution (Chap. 24 in Kofoed et al, 1934) and according to Kirby (1932) they contain the same species of cellulose-digesting protozoa. These are the large hypermastigote flagellates *Trichonympha collaris*, *T. campanula*, and *T. sphaerica*, and the smaller polymastigote, *Trichomas termopsidis*.

It is well established that *Zootermopsis* lacks the necessary enzymes for cellulose digestion (Cleveland, 1924; Hungate, 1938) and that these are provided by the protozoa. It is also certain that glucose is the product of the digestion (Trager, 1932). Cleveland has postulated that the glucose is absorbed and utilized by the termite. Trager (1934) succeeded in culturing *Trichomonas termopsidis* in the absence of all but one species of bacterium and reported experiments which were interpreted as indicating that glucose was the metabolic product of this protozoan, though glucose could not be demonstrated in the culture by chemical methods.

More recent investigations (Hungate, 1939) have shown that the protozoa in *Zootermopsis* carry on an anaerobic fermentation of cellulose and that carbon dioxide, hydrogen, and acetic acid are important products. Although estimates were made of the amount of cellulose decomposed, the quantity was too small to measure directly, and the possibility that glucose constituted a part of the metabolic products was not entirely excluded.

It is evident that the most satisfactory method to settle the details of the cellulose fermentation by the termite protozoa would be to obtain pure cultures of each species and perform quantitative experiments on the metabolism under carefully controlled conditions. However, methods for pure culturing these forms are lacking and in view of the abundance with which the protozoa occur in *Zootermopsis* and aided by the almost complete absence of cellulose-decomposing bacteria (Dickman, 1931; Hungate, 1936) it seemed probable that quantitative studies on the protozoa obtained directly from the termite would yield more

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exact information on the nature of the cellulose fermentation within the termite. It was also hoped that the knowledge gained might aid in the development of pure culture techniques for the protozoa.

Two methods can be used for the decomposition of measurable quantities of cellulose by suspensions of the termite protozoa. One is to use many animals for a short run; the other is to use fewer individuals and allow them to act for a longer time. The advantage of the short run lies in the fact that the action of bacteria is less important. There are several disadvantages. The weight of material decomposed is small in proportion to the weight of the protozoa and is of about the same magnitude as the errors in weighing and sampling. Also, errors due to death and cytolysis of the protozoa are relatively larger. Finally, it is uncertain in short runs whether cellulose or a storage product of the protozoa is the substrate metabolized. All these difficulties have made short experiments unsatisfactory so methods allowing longer experiments were developed.

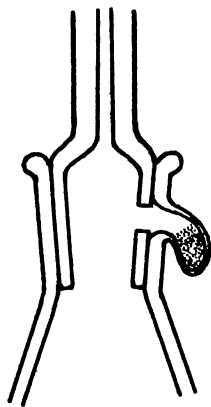


FIGURE 1. Arrangement of palladium black for hydrogen absorption.

Special Warburg respirometer vessels with a total volume of 75 ml. were constructed in order to permit use of larger quantities of medium. This assured longer survival of the protozoa before toxic concentrations of metabolic products were reached. A side arm on the vessel contained sulphuric acid which was added at the end of the run to liberate bound carbon dioxide. In the control vessel which contained a duplicate suspension of protozoa the acid was added at the beginning of the run. The amount of carbon dioxide produced in metabolism was obtained by subtracting the total carbon dioxide in the control from that in the experimental vessel. Acid production was calculated from the carbon dioxide evolved during the run in excess of that produced in metabolism. A tiny bulb blown on one side of the neck of the Warburg vessel (see fig. 1) was filled with palladium black for the absorption of hydrogen. This bulb was closed off from the main vessel during the run and opened at the end after bound carbon dioxide had been determined. The amount of hydrogen was calculated from the



drop in pressure during exposure to the palladium black. The gas volume included with the palladium in the side bulb was too small to cause any appreciable pressure change when opened to the main vessel. An extension of the open arm of the manometer, accommodating pressure changes of 800 mm. of Brodie solution, was arranged in order to measure the decomposition products of larger quantities of cellulose.

Suspensions of the protozoa were prepared by squeezing them directly from the termites into a salt solution which had previously been rendered anaerobic by bubbling with an oxygen-free mixture of 95 per cent nitrogen, 5 per cent carbon dioxide. Oxygen was absorbed with the chromous solution described by Stone and Beeson (1936). When washing of the protozoa was practiced they were allowed to settle to the bottom of a test tube, the upper portion of the liquid was pipetted off, and new medium added. This was performed three times. Powdered cellulose was suspended in water, boiled to drive off dissolved gas, and then centrifuged. The water was poured off and replaced by the suspension of washed protozoa. After mixing, equal amounts of the

TABLE I  
WEIGHTS OF CELLULOSE AND PROTOZOA IN EXPERIMENT 5

Experiment	5a	5b
Weight cellulose, beginning.....	19.5 mg.	19.0 mg.
Weight protozoa, beginning.....	2.1	3.1
Weight cellulose plus protozoa, beginning.....	21.6	22.1
Weight cellulose plus protozoa, end.....	17.3	18.0
Decrease in weight during run.....	4.3	4.1

suspension were transferred to the experimental and control vessels and with continuous shaking the gas mixture was passed through the manometers and vessels until all oxygen was removed and equilibrium between dissolved and gaseous carbon dioxide was reached. During the first runs the vessels were shaken only before readings since it was found that some of the protozoa became stuck on the sides. Later the shaking was decreased in amplitude and could be continuous without causing injury.

The medium in which the protozoa were suspended was: 0.1%  $\text{NaHCO}_3$ , 0.1%  $\text{NaCl}$ , 0.05%  $\text{KCl}$ , 0.01%  $\text{CaCl}_2$ , dissolved in pyrex-distilled water. It was necessary to increase the concentration of  $\text{NaCl}$  to 0.3% in order to obtain satisfactory survival of the protozoa from some colonies of termites.

At the end of the run the suspensions in control and experimental vessels were centrifuged, the supernatant fluid poured off for volatile acid determinations, and the residue dried and weighed. Eighty-five per cent of the acid produced was volatile, the remainder non-volatile. Acetic acid was found to be the only volatile acid formed; the non-volatile acids have not yet been identified.

In these experiments it was possible to maintain the protozoa in an active condition until they had decomposed measurable quantities of

materials, as determined from the difference between the weight of the residue in the experimental and control flasks. That this decrease in weight was due to digestion of cellulose and not to dissimilation of reserves in the bodies of the protozoa is indicated by the following experiment.

Suspensions of protozoa and cellulose containing known weights of each were used in a run lasting for 108 hours. The temperature was 25.5 degrees C. At the end of the experiment the combined weights of the protozoa and the remaining cellulose were determined. The data are presented in Table I.

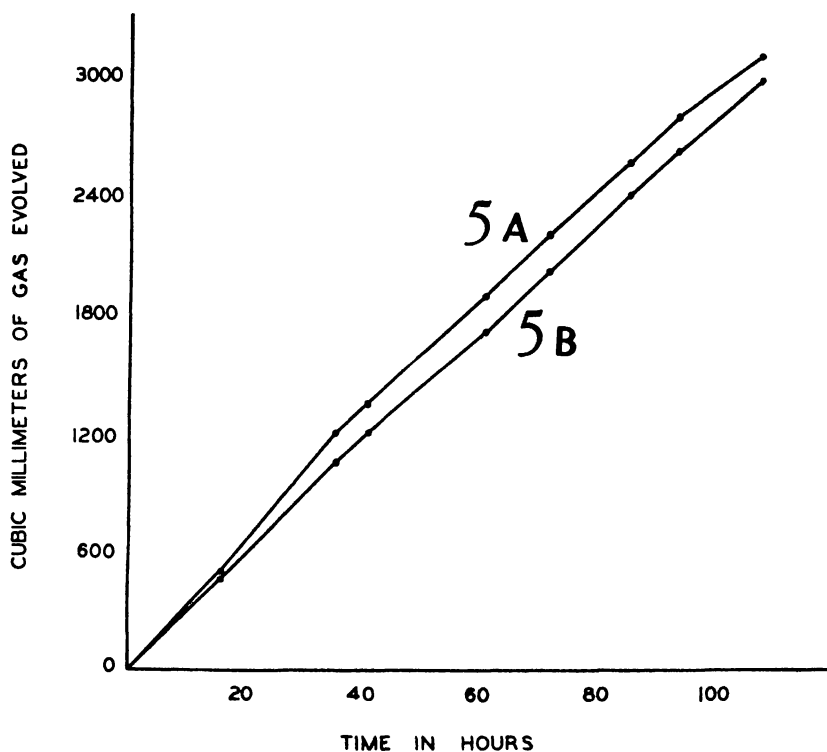


FIGURE 2. Gas evolution in experiments 5a and 5b.

It will be observed that the decrease in weight exceeds the total weight of the protozoa at the start. Since the great majority of the protozoa were alive at the end of the experiment and must have retained most of their original weight, it is evident that the loss in weight is due principally to the digestion of the cellulose. This conclusion is supported by the fact that protozoa in suspensions receiving no additions of cellulose survive only 24 hours, in contrast to the 108 hours of this experiment.

The amounts of gas evolved in the experimental vessels of experiment 5 are plotted against time in figure 2.

The uniform slope of the curves indicates that the products are formed by the protozoa and not by bacteria. If the gas evolution were due to bacteria growing during the run the rate would be expected to increase as the bacteria became more numerous. The constant rate indicates that the metabolic products are due to the protozoa and not to bacteria developing in the medium. The uniformity of the slope of each curve also shows that death of the protozoa during the experiment was negligible and that no growth of the protozoa occurred. Absence of a source of nitrogen in the medium would be expected to prevent growth.

Analyses of the products formed in experiment 5 and in similar runs provide information on the success in recovering the carbonaceous products of the protozoan fermentation of cellulose. These have been collected in Table II.

TABLE II  
AMOUNTS OF CELLULOSE DECOMPOSED AND CARBONACEOUS PRODUCTS  
FORMED BY THE PROTOZOA

Expt.	Cellulose Decomposed		CO <sub>2</sub> Formed		Acid Formed		Carbon Recovery
	mg.	mg. C	mg.	mg. C	mg.	mg. C	
1	2.7	1.20	0.61	0.17	1.90	0.76	77 percent
2	8.6	3.83	0.48	0.13	7.44	2.97	81
3	2.9	1.29	0.44	0.12	2.61	1.04	90
4	9.8	4.36	1.10	0.30	7.44	2.97	75
5a	4.3	1.91	1.76	0.48	2.22	0.89	72
5b	4.1	1.82	1.57	0.43	2.28	0.91	74
6a	5.0	2.22	2.16	0.59	2.89	1.16	79
6b	6.1	2.72	1.94	0.53	2.82	1.13	61

In Table II the amount of carbon in the acid formed has been calculated as if acetic acid were the only acid present. Since acetic acid constitutes only eighty-five per cent of the total acid it is possible that monobasic acids with three or more C atoms may be present in the remainder and, if so, the reported recovery based on two C atoms is too low. Also, the fact that acetic acid is weak and will not decompose bicarbonate with a quantitative liberation of carbon dioxide on a mol for mol basis causes the quantity of acid indicated in the table to be slightly less than the amount actually formed in the experiments. With these qualifications in mind it is evident that carbon dioxide and acetic acid constitute the major part of the carbonaceous products of the cellulose fermentation by the protozoa in *Zootermopsis*.

Tests have been made for other possible products of the cellulose fermentation by the protozoa. Examinations for neutral volatile materials have been made by distilling the slightly alkaline culture solution in a fractionating column and carefully observing the advancing rim of distillate for indications of surface tension differences between the water and any other volatile material. This method is sufficiently sensitive to detect easily one part of ethyl alcohol in 10,000 parts of water. No indications of neutral volatile materials were ever observed.

Tests were made for glycerine, acetylmethyl-carbinol, polyalcohols, and formic acid, but none of these materials could be detected. Small amounts of lactic acid were found in one experiment. Copper reduction tests for glucose were uniformly negative. This fact, coupled with the reasonably satisfactory recovery of fermentation products shows quite conclusively that glucose is not an important product in these experiments.

TABLE III  
MATERIALS FORMED IN THE FIRST TYPE OF CELLULOSE FERMENTATION

Expt.	Cellulose Disappeared	Carbon Dioxide	Hydrogen	Acid
1	17	14	16	32
2	53	11	14	124
3	18	10	5	44
4	60	25	26	124
Totals..	148	60	61	324
Ratios..	1	0.4	0.4	2.2

One of the most interesting features of the cellulose fermentation by the protozoa in *Zootermopsis* is that there are two general modes of decomposition resulting in the formation of the chief end products in strikingly different proportions. The first type of fermentation leads to the liberation of CO<sub>2</sub> and H<sub>2</sub> in approximately equimolar amounts and to production of acid in amounts exceeding the gaseous products. Table III presents the data pertaining to fermentations of this type. Amounts of gas are expressed in micromols (millionths of a mol), the cellulose as micromols of hexose, and the acid as microequivalents.

TABLE IV  
MATERIALS FORMED IN THE SECOND TYPE OF CELLULOSE FERMENTATION

Expt.	Cellulose Disappeared	Carbon Dioxide	Hydrogen	Acid
5a	27	40	65	37
5b	25	36	62	38
6a	31	49	85	48
6b	37	44	76	47
Totals..	120	169	288	170
Ratios..	1	1.4	2.4	1.4

The second type of fermentation results in the production of nearly twice as much hydrogen as carbon dioxide, and of an amount of acid equivalent to the carbon dioxide. The data for this type of fermentation are summarized in Table IV. The units are the same as in Table III.

It is apparent that the products occur in quite different ratios in the fermentations shown in Tables III and IV.

These two types of fermentation are not limited in occurrence to the protozoa in suspensions. They are also found in the faunated termites themselves. Thus, the amounts of hydrogen reported by Cook (1932), Gilmour (1940), and some of those reported by Hungate (1939) may be interpreted as due to the occurrence of the first type of fermentation. The hydrogen production in these experiments is of the magnitude of 20 cubic millimeters per gram of termites per hour. But one of the colonies studied by Hungate showed a hydrogen production of 214 cubic millimeters per gram of termites per hour. This large value clearly suggests the second type of fermentation.

The protozoa for experiments 5 and 6 were obtained from one colony of termites, those used in experiments 1-4 were from two others. The protozoa used in experiments 1-4 survived well in the inorganic medium containing 0.1 per cent NaCl. The protozoa of experiments 5 and 6 were soon dead when placed in this solution but if the NaCl concentration was increased to 0.3 per cent they showed excellent survival. These observations point toward definite differences between the protozoa of the two series of experiments.

The most logical explanation for these differences would be that the protozoa were not the same. Kirby (1932) records that the relative proportions of individuals of the several protozoan species may vary from colony to colony. Additional experiments were performed with protozoa from several new colonies in order to examine further the occurrence of these fermentation types. A fairly good correlation was found between the need for 0.3 per cent NaCl in the medium and a fermentation in which larger amounts of hydrogen were formed. But attempts to correlate with the relative numbers of different kinds of protozoa were unsuccessful. This is understandable when it is realized that information on the relative metabolic activity of individuals of the different protozoan species is completely lacking. In order to attempt evaluations of this sort it would be almost essential to have pure cultures of the protozoa.

The first type of fermentation has been found principally in colonies of *Z. nevadensis* whereas the second type is more common with *Z. angusticollis*. However, in the author's experiments several cases have been encountered in which the situation is reversed. The discrepancies might be explained as due to difficulties in properly classifying the two species of termites. However, using the distinctive features given by Sumner there was no uncertainty in assigning colonies to one or the other. Thus, fermentation type and morphological characteristics of the termite seem to occur more or less independently of each other. The fermentation variations are apparently concerned with the physiology of the protozoa but it might be expected that physiological peculiarities of the host would exert an influence on the proportions of the protozoa and thus indirectly on the type of fermentation exhibited.

Most of the available accounts of the swarming flight and mating reactions of termites suggest extensive and perhaps exclusive inbreeding. Male and female members of a pair are derived from the same colony. This has been discussed by Emerson (1935) as a factor concerned with

the evolution of two species of *Nastutitermes*. It might also explain the occurrence of the varied fermentation types exhibited by colonies of *Zootermopsis*.

In these experiments it is evident that the protozoa ferment most of the glucose formed through digestion of the cellulose. No glucose can be demonstrated as a metabolic product. However, the conditions of the cellulose fermentation by the protozoa within the faunated termite differ from the conditions in the *in vitro* cultures. If at any time the rate of digestion of cellulose by the protozoa were greater than the rate of fermentation of the glucose formed then glucose would accumulate. Failure to demonstrate glucose in the *in vitro* experiments could be explained by its presence in concentrations too small to be detected by chemical means. Thus, the information gained from the *in vitro* cultures cannot alone determine conclusively the importance of glucose to the termite. However, using also data on the oxygen consumption and hydrogen production of the faunated termite an evaluation can be attempted.

The results of Cook (1932) and Gilmour (1940) indicate that the hydrogen production in faunated termites is about 10 per cent of the oxygen consumption. The protozoa in the termites studied by them apparently exhibited a fermentation of the first type reported in this paper. The *in vitro* studies of this fermentation (Table III) show that the amount of acid formed (principally acetic acid) is about five times the hydrogen production. If the protozoa in the termite accomplished this same type of fermentation, and the evidence supports this assumption, then the acid formed by the protozoa in the termite would be equal to about one-half of the oxygen consumed. Earlier results (Hungate, 1939) show that this acid is completely absorbed. Assuming that it is completely oxidized it is evident from the equation



that 2 mols of oxygen will be needed for the combustion of one mol of the acid. Since the amount of acid produced in the termite is about one-half the amount of oxygen consumed it is evident that combustion of the acid accounts satisfactorily for the oxygen consumption.

Estimates can also be made for the second type of fermentation. A colony of *Z. angusticollis* showed a hydrogen production of 9.5 micromols (214 cubic millimeters) per gram of termites per hour. From the data obtained for *in vitro* fermentations of this type (Table IV) the hydrogen and acid occur in the proportion of 2.4 to 1.4. Thus 5.8 micromols of acid per gram hour were formed within the termite. This amount of acetic acid would require 11.6 micromols of oxygen for its combustion. Actually, the oxygen consumption was 17.2 micromols per gram hour. Although at first sight this would seem to leave 5.6 micromols of oxygen that might have been used for glucose combustion yet it should be recalled that the recovery of carbon in the *in vitro* experiments was incomplete. In experiments 5 and 6 (Table II) the carbon in the unidentified products amounted to more than one-half the carbon in the acid, and the combustion of these materials could well account for the remaining 5.6 micromols of oxygen. Thus, also in this fermentation type the products of the fermentation by the protozoa seem to be suf-

ficient to require for their combustion an amount of oxygen about equal to that taken up by the termite.

While these are extremely rough estimates they point definitely toward the conclusion that the principal carbonaceous materials used by *Zootermopsis* are the fermentation products formed by the protozoa from the glucose which they obtain by cellulose digestion. Direct examination of the processes occurring in most other species of termites is handicapped by the small size of the hosts but it has been possible to obtain protozoa from *Reticulitermes claripennis* in sufficient numbers to examine them for a fermentative metabolism. Gas and acid were found to be produced and acetic acid could be identified as one of the products.

It is highly probable that an anaerobic fermentation process is characteristic of most of the wood-digesting protozoa found in termites and in the closely related wood roach, *Cryptocercus punctulatus*. The ease with which all these protozoa can be killed by increasing the oxygen tension (Cleveland, 1925, 1934) strongly points toward their obligate anaerobic nature; and in the necessary absence of oxygen they must perforce carry on a fermentative metabolism in order to satisfy their energy requirements.

The question of the site of absorption of metabolic products of the protozoa has been examined in *Zootermopsis*. The alimentary tract of a large nymph of *Z. angusticollis* was removed and the hind-gut was carefully ligated at each end. It was left overnight in a small tube of inorganic culture solution. The following morning the gut was still intact and upon testing the surrounding fluid for acetic acid it was found to be present. It may be concluded that the chitinous intima and the wall of the hind-gut are permeable to this product of the protozoan fermentation and probably also to the non-volatile acids. The termite oxidizes these materials to obtain its necessary supply of energy. The carbon dioxide produced by the protozoa is eliminated from the termite and so also is the hydrogen.

## SUMMARY

1. Using large Warburg vessels the decomposition of weighed amounts of cellulose by protozoa from termites of the genus *Zootermopsis* has been studied. The protozoa were obtained directly from the alimentary tract of termites, washed in a suitable inorganic medium, and allowed to act upon cellulose for periods up to 108 hours.

2. The cellulose disappearing could be recovered to the extent of 70-75 per cent as the products: carbon dioxide, hydrogen, and acids, principally acetic acid. The possibility that bacteria were concerned with the formation of these products was considered and their action shown to be negligible.

3. Protozoa from different colonies of *Zootermopsis* show differences in their metabolic products and in their salt requirements. These are possibly due to differences in the proportions of the protozoan species present.

4. From the amount of hydrogen produced in the faunated termite and from the ratio in which the fermentation products appear in *in*

*vitro* experiments a quantitative estimate of the fermentation products formed by the protozoa within the termite can be made. These products are sufficient in amount for their oxidation to account for the observed oxygen consumption of the termite. It thus seems improbable that glucose is absorbed to any great extent.

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THE PSYLLIDS OF AMERICA NORTH OF MEXICO (PSYLLIDAE: HOMOPTERA), by LEONARD D. TUTHILL, reprinted from Ia. St. College, Jour. of Science, xvii, No. 4, July, 1943, pp. 443-660, 19 pls. Price \$2.00.

Psyllids are often overlooked by collectors due to their small size and fragility, as well as to their elusive habits when swept or beaten into a net. However, they have not been overlooked in recent years, especially by Caldwell and Tuthill, who seem to have found means of capturing them.

Since Fitch in 1851 described six species, the number has increased until 148 species are presented in Tuthill's scholarly monograph. In every detail his work shows a thorough treatment of adequate material. Each scientific name is explained or interpreted in a footnote, a commendable minutia. As an incorporation of the knowledge of the jumping plant lice this work will serve entomologists well.—DOROTHY J. KNULL.



## TWO UNUSUAL VESPULA NESTS

RAYMOND C. OSBURN,  
Ohio State University,  
Columbus, Ohio

Since the behavior of insects is always of interest it seems worth while to record a nest of the black hornet, *Vespula maculata* (L.), built flat on the ground, while a couple of rods from it there was a nest of the yellow-jacket, *Vespula arenaria* (Fabr.), situated 15 feet above ground on the limb of a tree. The writer has observed hundreds of the nests of the black, or bald-faced hornet, but the one here described appears to be unique. The altitude of the nest ranges widely, to be sure, from two to three feet in bushes up to 30 or 40 feet high in trees, but this variation involves no change in the construction of the nest.

*Nest of Black Hornet* (figs. 1 and 2).—The nest was shaped somewhat like the American soldier's "tin hat" of the first world war, evenly rounded over the top and flared out around the lower edge to form a brim. Seen from above it was rather regularly elliptical, 14 by 16 inches in diameters, the height at the center six inches. The entrance hole was low down on one side, within a quarter of an inch from the ground, so that the workers approaching the nest sometimes alighted on the small paper platform but more frequently on the bare ground (fig. 2).

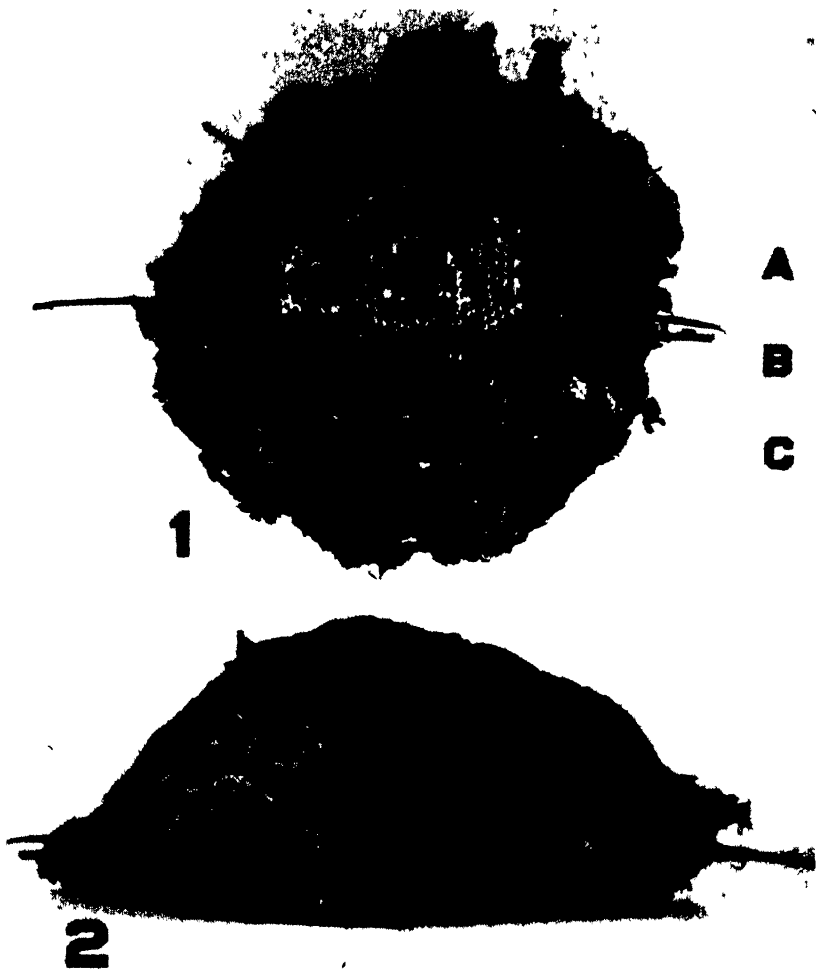
In the ordinary hornet's nest the walls are thickest above and thin out considerably on the sides and below. In the one under discussion only the upper wall was present and where it approached the ground it was expanded both outwardly and inwardly. Where it touched the ground the nest wall varied from two to three and one-half inches in thickness, the inner edge being turned under one-half to one inch. This lateral extension probably served to keep the rain from splashing up inside of the nest.

Beneath the nest the ground was swept perfectly clean of everything that could be moved. A few twigs and a couple of pebbles were too large to be handled and the nest was built around them. Also a trailing grapevine a couple of inches above the ground was incorporated and an erect weed stem projected upward through the nest a little to one side of the center.

The brood combs occupied a space about eight by nine inches across in the middle of the nest, as shown in figure 1, and were in three layers. The largest was uppermost and complete; a second layer about half as large covered a part of the first below and extended sidewise beyond it; the third layer, covering a part of the outer edge of the second, was apparently not completed in time to be used, with the exception of a few cells. The two layers of completed comb contained approximately 450 cells.

The colony, which was a large and very active one, was located on a dry bank within about a foot of the wheel tracks of a little-used forest road. It was surrounded by vines and weeds on all sides except in

front, so the hornets leaving the nest were compelled to take off into the roadway before dispersing. One could approach readily to within a few feet of the nest along the roadway, but these hornets had lost none of their temperament in the lowly disposition of their nest. Several



Nest of *Vespula maculata* (L.). Figure 1. Under side of nest showing the three layers of comb opposite A, B and C. Note thickness of nest wall at the ground level. 2. Side view of nest showing entrance, with horizontal grapevine and erect weed stem passing through the nest.

of the workers were collected during the season and a larger number were found dead in the nest at the close of the warm weather.

The nest was first discovered by Dr. L. Y. Lancaster, of State Teachers College, Bowling Green, Ky., about the end of August and was

under observation by the writer until the hornets deserted it after the coming of frost in October. The site was South Bass Island in Lake Erie, where typically constructed nests are often observed. The nest is now preserved in the insect collections of the Ohio State University.

I have shown this nest to many entomologists and naturalists and questioned many others, but no one seems to have observed one like it. In searching the literature I have found but one reference to a nest which touched the ground. Mr. Wm. T. Davis (Brooklyn Ent. Soc. Bull., 14: 120) makes mere mention of a nest which "had no paper between the lower comb and the ground; it had been started too low down." Philip Rau (Ann. Ent. Soc. Amer., 22: 666-7) reports that a portion of the wall of a nest which he collected for study had become torn off and lodged a few inches from the ground. The few remaining hornets used this as a home and even built small combs beneath it. However, there was little attempt at reconstruction of the nest and the hornets came and went through an accidental tear in the cover.

Rau's observation suggests that possibly the nest here described might have been dislodged from slightly higher up and the hornets did not desert it. If such were the case they remodeled it so completely and symmetrically that there remained not the slightest evidence of an accident. On the other hand it may have been started too close to the ground and simply widened when it came into contact. Nests built beneath the eaves or window caps of buildings are usually molded on one side to conform to the space.

*Nest of Yellow-jacket.*—The yellow-jackets in general select protected places, usually under ground, or in holes in stumps or logs, but *Vespa arena* Fab. does sometimes build above ground, either low down where the nest is well protected by weeds and shrubbery, or occasionally higher up under the eaves of lower buildings. The nest here described was attached to the horizontal limb of a maple tree, out in the open, fifteen feet above the ground, and as much exposed as the nests of the black hornet often are. It had all the general appearance of the ordinary pear-shaped black hornet nest, but its texture was much more delicate and the walls thinner. The nest was about nine inches high by seven wide and the aperture was located on one side about two inches above the lowest point. The main comb was circular and about five inches in diameter. Below this was a second comb three and a half inches across. The colony, which was a very busy one, was under observation for a couple of months and was collected about the middle of October after it was deserted. While the nests of the yellow-jacket are abundant enough, this is the first one I have ever noted in the open more than a foot or so above the ground.

A further oddity was the unprotected nest of *Polistes fuscatus* F. a couple of inches across, attached to a grapevine stem two feet above the nest of the black hornet. While in some of the drier parts of the country wasps' nests frequently occur in the open, it is very unusual in Ohio to find one unprotected even by foliage. It would seem that something must have seriously upset hymenopteron psychology in that particular locality.

# POPULATION STUDIES OF TWO SPECIES OF ANTS, *LEPTOTHORAX LONGISPINOSUS* ROGER AND *LEPTOTHORAX CURVISPINOSUS* MAYR.

A. E. HEADLEY,  
Ashtabula, Ohio

Population studies of social insects, while on the increase, are still in the beginning stages. Possible reasons for this lack of study are: (1) taxonomic and economic studies have dominated the field, (2) there is lack of interest in population problems by those who have the necessary background knowledge of social insects, and (3) there are difficulties in controlling the environment of social insects in such a way that successful laboratory studies may be made upon them. However, social insects are valuable for population studies because of the fact that each colony is a closed unit of society which shows all the phases of population phenomena of incipency, growth, and decline. Moreover these populations are stable units of a restricted environment, because each centers around a nest which is usually maintained in one particular spot throughout the life of the colony. Ants are favorable social insects for population studies because they are so abundant, so numerous in varieties, and so varied in habitat.

Few population studies of ants have been made and such work as has been completed has been largely the incidental counting of colonies or individuals of colonies as part of some other ant study. Various population studies should include such intraspecific social relationships as size of colony, proportion of all phases of brood to adults, egg fertility, time span of each developmental stage, length of adult life, colony development and decline, and nest construction as an expression of colony activity. They should include such interspecific social relationships as average size variations of colonies within a species, distribution of nests within a restricted habitat, the amount of territory each colony needs to maintain itself, and the relationship of the ant population to the ecological community as a whole. This paper attempts to work on only one phase of these problems, namely, to make a quantitative study of the ant *Leptothorax longispinosus* Roger, and to a smaller extent the closely related *Leptothorax curvispinosus* Mayr, as to variation in size of colonies and relationships of all developmental stages throughout the seasons of a year, in a restricted nest habitat (acorns) and in a restricted ecological environment (an oak woods bordering on a beech-maple-hemlock ravine).

This phase of population study is fundamental to further work but to date it has been rather restricted in extent. Talbot's (1943) work on *Prenolepis imparis* is perhaps the most complete since it carried on a year's study and included counts of eggs as well as larvae, pupae, and adults for 20 colonies. Wesson (1939) counted 31 colonies of *Harpagoxenus americanus* which were parasitizing colonies of *Leptothorax curvispinosus*, and Wesson and Wesson (1940) recorded 8 nests of the

*Leptothorax schaumii*-*Leptothorax fortinodis* group. Pricer (1908) counted 24 mature colonies of *Camponotus herculeanus pennsylvanicus* and its variety *ferrugineus* but he counted in the winter when only adults, winged forms and larvae, were present. Pickles (1940), over a period of five years, made counts of 16 colonies of *Lasius flavus*, 27 of *Formica fusca* and 29 of *Myrmica ruginodis* but in these counts eggs were ignored, no attempt was made to procure a year round picture of population fluctuation, and some of the records represent recounts of colonies which had been dug and then returned to their nesting site with the expectation that they would reorganize and thrive as usual. This technique, as Pickles himself admits, is not a suitable method of studying ant populations since the colony is thoroughly disrupted by such treatment. Other countings have been fragmentary in nature and include such records as: 6 colonies of *Formica rufa* (Andrews, 1929), 3 of *Formica exsectoides* (Cory and Haviland, 1938, and Andrews, 1929), 2 of *Leptothorax curvispinosus* (Sturtevant, 1925), and one each of *Formica rufa obscuripes* (Weber, 1935), *Eciton hamatum* (Schneirla 1934), *Prenolepis imparis* (Dennis, 1941), *Solenopsis fugax*, and *Monomorium pharaonis* (Donisthorpe, 1915).

The ants *Leptothorax longispinosus* and *Leptothorax curvispinosus* were chosen for this study because in previous collecting a place had been found in which these ants were unusually available, nesting in acorns. The acorn nests are considered valuable because they give a definite, restricted, and uniform nesting space for each colony, and they can be collected abundantly.

*Description of the Collecting Area.*—The ants were secured in Ashtabula County, Ohio, approximately a mile and a half southwest of the village of Harpersfield. The collecting ground is a part of the R. T. Hauptfear farm and may be located by traveling from Harpersfield southward on route 534 until it makes a left angle, at which point a macadam road leads directly ahead. The woods is on the right side of the macadam three hundred yards west of the main road.

This part of Ohio is unique in that it is cut by a series of hemlock ravines bordering on Lake Erie. As the Grand River cut its way westward through a terminal moraine it dug a deep gulf 25 to 125 feet deep along its course into Lake Erie. In this region on the south side of the gulf are many deep ravines leading into this main one. The ravines leave fingerlike projections of upland which are sometimes wooded, sometimes merely fringed with woods, for 20 feet or more back from the ravine. These upland woods form a beech-maple climax with a scattering of oaks, shagbark hickory, elm and ash. Near the top border of the ravines, where the ants were collected, is a mixed woods of white, red, chestnut and scrub oaks and white pine, with an occasional beech or maple tree. Here the ground vegetation is very sparse due to the poor quality of the clay-and-shale mixture found along the top edges of the ravines. There are some hazelnut bushes, ground pine, wild grape-vine runners, a little moss, and tufts of grass here and there. Some flowers bloom in the spring before the trees shade the ground but no conspicuous flowers of summer or fall are found. In some spots the fallen leaves are blown over into the ravine below leaving

the ground barren. This is a great aid in collecting acorn nests. The soil is very moist during the rainy season of the year but drains off so quickly that it is usually hard and dry. This condition proves very favorable for ant nests in acorns because the rapid drainage and scarcity of dead leaves prevents mold from accumulating in the nuts.

*Distribution of Nests.*—*Leptothorax longispinosus* nests occur most abundantly about 15 feet from the rim of the ravine, where shade of trees is dense, while *L. curvispinosus* are more numerous under the outer branches of the fringe of oak trees, where the sun penetrates. Acorn nests are the predominant nests in the area. In the months of collecting no ant nests were seen in the ground nor were any located in dead sticks on the ground. One *Aphaenogaster tennesseensis* nest occurred in a large beech tree which had fallen over, but, aside from this, acorns were the main habitat in the area collected. Beside the *Leptothorax* species, the acorns housed *Ponera coarctata pennsylvanica* Buckley, *Crematogaster lineolata* Say, *Myrmecina graminicola americana* Emery, *Myrmica punctiventris* Roger, and *Brachymyrmex heeri depilis* Emery. Acorns seem to form unusually fine niches for many kinds of insects. With the exception of each year's new fall, there is a 95% infestation by some kind of insect. The acorn supplies many larvae with abundant food as well as an excellent protection against predators. The 5% not inhabited by insects usually have some kind of life in them: spiders, snails, mold, etc.

*Density of Population of Nests per Area.*—In order to determine the abundance of ant colonies and ants in this habitat two areas 50 feet long and 5 feet wide were selected, giving twenty 5-foot-square plots, and the positions of all the acorn ant nests in these plots were recorded on squared paper as the colonies were collected for counting. On this 500 square feet of ground there were found 58 acorn nests which consisted of 41 of *L. longispinosus*, 13 of *L. curvispinosus*, 2 of *Myrmecina graminicola americana* and one each of *Myrmica punctiventris* and *Ponera coarctata pennsylvanicus*. This gave an average of 2.9 nests for each 5-foot square, of which 2.1 were *L. longispinosus* and .65 were *L. curvispinosus*. When all of the 58 colonies were counted it was found that they gave a total of 8962 ants in the 20 plots or an average of 448.2 for each 5-foot square. There were 3180 worker ants in the 20 plots or an average of 158.0 workers for each 5-foot square. Thus on every square foot of ground there were 6.4 workers foraging for food to feed 17.9 ants (workers plus brood).

In order to determine the proportion of acorns inhabited by ants the total number of acorns lying on the ground were counted for several 5-foot squares and they were found to average 27.5. Acorn ant nests averaged 2.9 nests per 5-foot square, which equals 2.9 nests per 27.5 acorns or one nest for 9.5 acorns.

In these plots there were 3.2 *L. longispinosus* to every *L. curvispinosus* and in the complete collection of 132 colonies the proportion was 2.8 *L. longispinosus* to every one *L. curvispinosus*. This was due to the fact that collecting was done beneath the dense shade of trees. If the collecting area had been in the more open, sunny places, the proportion of the two species might have been reversed.

*Description of the Acorn Nest and of the Colony Within It.*—The acorns are approximately  $\frac{3}{4}$  inch long and  $\frac{1}{2}$  inch at the greatest diameter. They are usually of white oak although there are red oak nests also. The ones used by the ants are several years old; those too hard to be broken easily with the fingers never have colonies in them. There is no break in the surface except for the little round entrance, which is always a perfectly symmetrical opening  $\frac{1}{16}$  inch in diameter. It is located in the area of greatest diameter or at the edge of the cap where it fits down over the acorn, never in the narrow end. The normal position of the entrance is along the side close to the ground; if the entrance is at the top side, the acorn has been disturbed by wind or by some animal. Occasionally it is next to the ground on the under side; in this case there is usually a little circle of soil stuck onto the acorn around the hole. Sometimes a leaf will be stuck to the acorn and the entrance will penetrate through this.

The shell is always tight enough so that even in winter when snow covers the acorn it never becomes soggy. The nest may become bone dry during drought periods but it usually contains some moisture. Ants are never found in a moldy acorn or a soggy one. There is little debris inside and this is composed chiefly of tiny pellets. Occasionally a part of the kernel is still there; in that case the nest is divided into compartments. Generally the acorn is entirely hollow, with the larvae lying on the bottom next to the ground. The inside surface of the shell is almost always laminated and much of the brood lies in the crevices. Winter conditions of the nest are the same as summer conditions except that in the winter the workers and larvae are massed into a ball with the queen in the center.

*Season of Activity for Leptothorax.*—The months of active foraging are from April to the middle or latter part of October, depending on the weather. However, when the temperature has cooled off to somewhat below 50° F., there is no further evidence of outside foraging even though the temperature should rise for a short period. This is not like the mound-building *Formica* for they will appear at the surface during the winter if the temperature rises above 44° F. (Weber, 1935). *Leptothorax* are not entirely immobile during hibernation, for, when a nest is opened during the winter, antennae will wave slowly and legs will move somewhat. The spring of 1942 was unusually wet and cool and more workers were seen out on the ground than had ever before been observed by the writer. The temperature at which they were most active was between 60° and 70° F. *L. curvispinosus* consistently moved faster than did *L. longispinosus*.

*Population Counts of Leptothorax longispinosus.*—A total of 97 *L. longispinosus* colonies were collected and these had an average population of 135.9. The largest colony had 419 members, of which 141 were workers. The average number of workers to a colony was 45.8. These small colonies are typical of many ants which live in inconspicuous, out-of-the-way crevices and are in contrast to colony populations of medium strength such as *Prenolepis imparis* with its mean population of 1519 (Talbot, 1943) or those of tremendous size whose workers alone may total the 8,228 of *Formica exsectoides* (Andrews, 1929), the 30,000

of *Eciton hamatum* (Schneirla, 1934), or the 237,103 of *Formica exsectoides* (Cory and Haviland, 1938). The confines of an acorn do not seem to restrict colony size in any way, for these colonies average as large as or larger than those collected from snail shells, twigs, and the like. There is no evidence that *Leptothorax* ever reach a colony size which forces them to move from the acorns.

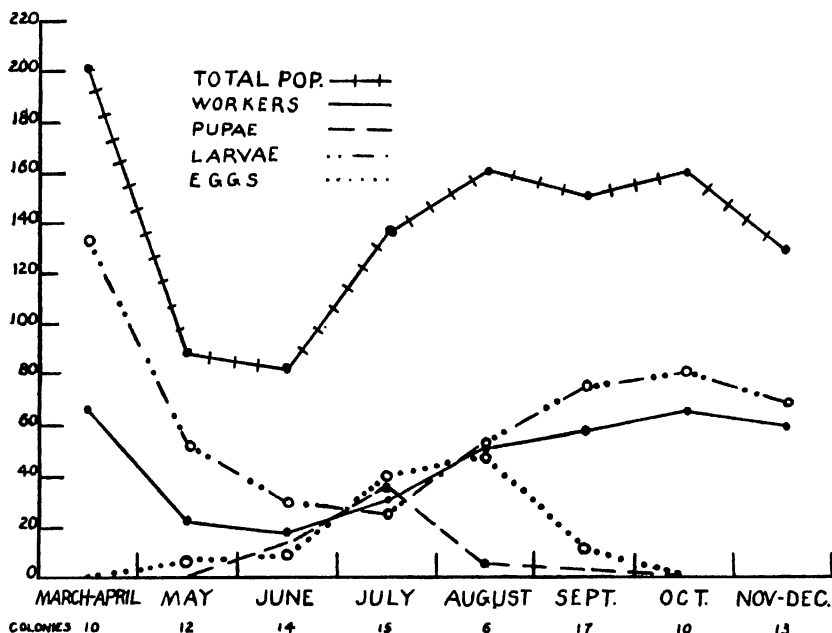


FIGURE 1. Population counts of *Leptothorax longispinosus* colonies throughout the year, showing fluctuations in numbers of eggs, larvae, pupae, and adults at the various seasons of the year.

*L. longispinosus* overwinters many larvae of small to medium size. In the inactive months, when no other brood was present, there was an average of 1.6 larvae to every worker or 61.2 to the colony. Larvae began their spring growth by the first of May and by May 10 (1942) a number had grown to full size, while the rest remained medium to small in size. Evidently a few had been selected for the early feeding. By May 31 some larvae were found that were larger than adult workers and were destined to become females. The overwintered larvae did not begin to pupate until the second week of June. Egg laying began about the middle of May, but no record of hatching was obtained because spring larvae could not be distinguished from the retarded overwinter ones. Egg laying continued into September. During late June and July there were male and female as well as worker pupae in the nests, but the August and September pupae were all worker. Pupation ceased during the early part of September and all the remaining larvae overwintered in the nest.



Workers reached their lowest numbers in June, before the year's crop of pupae had begun to emerge, and built up to their full strength by September, when pupation ceased. At all seasons of the year the immature forms more than equaled the adults and in the total population of 97 colonies there was one worker for every three colony members (workers plus brood). (See fig. 1.)

Queenless (?) colonies were amazingly abundant, 34 of the 97 colonies being without dealate queens. Fourteen of these can be accounted for by the fact that they were parasitized by *Harpagoxenus americanus* and so may have had their queens killed by the invaders. Of the remaining 20, only 4 were obviously decadent in that they had no eggs at a time when eggs would be expected. The other 16 colonies might have recently been deprived of a queen, the queen might have been out of the nest at the time when it was collected, or workers might have taken over the function of laying. This subject of substitute and parthenogenetic egg-laying has recently been reviewed by O. Macken-son (1943) in the case of the honey bee.

*Parasitism.*—The slavemaking *Harpagoxenus americanus* was found 15 times associated with *L. longispinosus*. This number gives an average of 1 to 6.5 infestation. In a previous collection by the writer 24 nests of *L. longispinosus* had 3 invaded by *Harpagoxenus*, or an average of 1 to 8. The proportion is similar to the proportion of 1 to 7.8 of Sturtevant (1927) and is considerably greater than the 1–15 ratio given by Wesson (1939) and tends to confirm Wesson's view that the dulotic *Harpagoxenus* is not so rare as has been supposed. Wesson and Sturtevant found their *Harpagoxenus* in *L. curvispinosus* nests but, strangely enough, in this acorn collection *Harpagoxenus* were confined to *L. longispinosus* and were never found parasitizing *L. curvispinosus*. Of the 15 colonies collected, 4 were evidently recently invaded by a queen for there were no *Harpagoxenus* workers; 7 colonies represented well established relationships with workers as well as having the parasitic queen present; while 3 colonies represented what Wesson calls "secondary colonies" or establishment of mixed colonies by a few workers which stay behind in a raided colony and take up residence with the remnants of the *Leptothorax*. One colony had a *Leptothorax* female in addition to the *Harpagoxenus* queen.

*Population Counts of L. curvispinosus.*—While the study of *L. longispinosus* was the main objective, enough *L. curvispinosus* nests occurred in the acorns of the woods to make it seem worth while to collect these in order to compare and contrast the two closely related species. There were 38 *L. curvispinosus* colonies collected and these had an average population of 235.0 members. The largest colony had 727 members, of which 369 were workers. The average number of workers to a colony was 82.6, which is almost twice the number in the *L. longispinosus* colonies. As in *L. longispinosus* small to medium sized larvae were overwintered. During the inactive months, when only workers and larvae were present in the nest, there was an average of one worker to 1.3 larvae. Spring egg laying began in the middle of April, a month earlier than for *L. longispinosus*, and continued until the early part of September. By Oct. 20 all eggs had developed into larvae. These

larvae were retained in the nest all winter and began to pupate during the early part of the following June.

Queenless colonies were even more abundant than with *L. longispinosus*, almost one third of the colonies being without functional queens.

*L. curvispinosus* are much more active and move more quickly than *L. longispinosus*. No *L. curvispinosus* colonies were found parasitized by *Harpagoxenus americanus*.

TABLE I  
POPULATION COUNTS OF COLONIES OF *Leptothorax longispinosus* ROGER

Date	Queen	Worker	Male	Female	Pupa			Larva	Egg	Total in Colony
					w.	m.	f.			
3-28-42	1	8	.....	.....	.....	.....	.....	8	.....	17
	2	82	.....	.....	.....	.....	.....	165	.....	249
	1	141	.....	.....	.....	.....	.....	277	.....	419
	2	36	.....	.....	.....	.....	.....	52	.....	90
	1	108	.....	.....	.....	.....	.....	175	.....	284
	.....	40	.....	.....	.....	.....	.....	40	.....	80
	1	90	.....	.....	.....	.....	.....	167	.....	258
	2	46	.....	.....	.....	.....	.....	114	.....	162
4-10-42	1	60	.....	.....	.....	.....	.....	144	.....	205
4-26-42	.....	64	.....	.....	.....	.....	.....	194	.....	258
5- 3-42	.....	5	.....	.....	.....	.....	.....	37	.....	42
	1	6	.....	.....	.....	.....	.....	25	.....	32
	1	16	.....	.....	.....	.....	.....	43	.....	60
5-10-42	.....	30	.....	.....	.....	.....	.....	104	.....	134
5-17-42	1	16	.....	.....	.....	.....	.....	24	1	44
	.....	2 <sup>1</sup>	.....	.....	.....	.....	.....	29	4	47
	.....	14	.....	.....	.....	.....	.....	112	1	149
5-24-42	1	56	.....	.....	.....	.....	.....	79	26	162
	1	16	.....	.....	.....	.....	.....	49	10	76
5-31-42	1	33	.....	.....	.....	.....	.....	82	25	141
	1	12	.....	.....	.....	.....	.....	71	22	106
	1	28	.....	.....	.....	.....	.....	47	6	82
6- 7-42	1	13	.....	.....	6	.....	.....	45	7	72
	.....	5	.....	.....	.....	.....	.....	17	.....	22
	.....	11	.....	.....	.....	.....	.....	68	.....	79
6-14-42	1	42	.....	.....	7	.....	.....	140	34	224
	.....	21	.....	.....	5	.....	.....	49	18	93
	1H <sup>2</sup>	7	.....	.....	.....	.....	.....	6	.....	14

<sup>1</sup>*Leptothorax curvispinosus*.

<sup>2</sup>*Harpagoxenus americanus*.

TABLE I—(Continued)

Date	Queen	Worker	Male	Female	Pupa			Larva	Egg	Total in Colony
					w.	m.	f.			
6-21-42	1H	18	.....	.....	7	.....	.....	1	4	31
	1	9	.....	.....	22	.....	.....	19	8	59
	1	7	.....	.....	4	.....	.....	126	19	157
	1	1	.....	.....	4	.....	.....	22	2	30
6-28-42	1H	16	.....	.....	22	.....	.....	9	1	49
	1H	64, 5H	.....	.....	11	7	45	27	40	200
	.....	21, 2H	.....	.....	11	7	8	6	.....	55
	.....	18, 2H	.....	.....	19	15	6	6	.....	66
7- 5-42	1	6	.....	.....	14	.....	.....	14	22	57
	1	23	.....	.....	40	.....	.....	79	44	187
	1H	52, 7H	.....	.....	16	5	19	3	21	124
	.....	16	.....	.....	10	11	7	3	.....	47
7- 9-41	1	22	.....	.....	32	.....	.....	40	82	177
	1	28	.....	.....	92	.....	.....	47	75	243
	.....	31	.....	.....	92	.....	.....	44	26	193
7-10-41	1	5	.....	.....	10	.....	.....	24	28	68
	.....	8	.....	.....	16	.....	.....	5	31	60
	1	22	.....	.....	1	1	.....	5	6	36
7-12-41	2	43	.....	.....	54	13	.....	41	68	221
	1	36	.....	.....	52	.....	.....	26	74	189
	.....	86	.....	10	47	1	15	48	49	256
	.....	7	.....	10	2	.....	2	.....	.....	22
	.....	55, 6H	.....	7	.....	5	1	8	105	187
8-16-41	1	54	1	.....	2	2	.....	84	109	252
	1	43	.....	.....	17	.....	.....	80	73	214
	1	38	.....	.....	1	.....	.....	38	39	117
	.....	13	3	3	1	.....	.....	63	25	108
	1	125	.....	.....	3	.....	.....	1	.....	130
	1	41	.....	.....	9	.....	.....	58	44	153
9- 2-42	.....	51	.....	.....	.....	.....	.....	14	1	66
	1	11	.....	.....	2	.....	.....	38	3	55
	1	90	.....	.....	8	.....	.....	73	20	192
	1	105	.....	.....	26	.....	.....	207	16	355
9- 4-41	1	79	.....	.....	8	.....	.....	114	10	212
	1H	33, 3H	.....	.....	2	.....	.....	12	30	81
	1H	29	.....	.....	4	.....	.....	7	18	59
	1, 1H	157, 12H	.....	.....	1	.....	.....	183	38	393
	.....	79, 6H	.....	.....	2	.....	.....	112	28	227
	1	40	.....	.....	.....	.....	.....	74	7	122
	1	84	.....	.....	8	.....	.....	106	13	212
	1	28	.....	.....	3	.....	.....	73	4	109
	1	1	.....	.....	1	.....	.....	4	.....	7
	1	46	.....	.....	.....	.....	.....	112	7	166
	.....	37	.....	.....	3	.....	.....	47	.....	87
	1	39	.....	.....	5	.....	.....	51	6	102
	1	74	.....	.....	1	.....	.....	67	.....	143

TABLE I—(Continued)

Date	Queen	Worker	Male	Female	Pupa			Larva	Egg	Total in Colony
					w.	m.	f.			
10-11-42	1H	99, 5H	.....	.....	.....	.....	.....	35	.....	140
	4	68	.....	.....	.....	.....	.....	195	.....	267
	1	44	.....	.....	.....	.....	.....	97	.....	142
10-20-41	4	79	.....	.....	.....	.....	.....	192	.....	275
	.....	10	.....	.....	.....	.....	.....	13	.....	23
10-24-42	1	92	.....	.....	.....	.....	.....	65	.....	158
	4	36	.....	.....	.....	.....	.....	172	.....	212
	1H	77, 6H	.....	.....	.....	.....	.....	33	.....	117
	2	78	.....	.....	.....	.....	.....	101	.....	181
	.....	78	.....	.....	.....	.....	.....	20	.....	98
11-17-41	1	96	.....	.....	.....	.....	.....	146	.....	243
12-14-40	.....	21	.....	1	.....	.....	.....	50	.....	72
12-23-40	1	8	.....	.....	.....	.....	.....	14	.....	23
	1H	144, 4H	.....	.....	.....	.....	.....	53	.....	202
	1	35	.....	.....	.....	.....	.....	81	.....	117
	1	37	.....	.....	.....	.....	.....	52	.....	90
12-24-40	1	27	.....	.....	.....	.....	.....	36	.....	64
	1	27	.....	.....	.....	.....	.....	49	.....	77
	1	74	.....	.....	.....	.....	.....	104	.....	179
	1	66	.....	.....	.....	.....	.....	49	.....	116
	1	77	.....	.....	.....	.....	.....	56	.....	134
	1	89	.....	.....	.....	.....	.....	87	.....	177
	1	95	.....	.....	.....	.....	.....	106	.....	202

TABLE II

POPULATION COUNTS OF COLONIES OF *Leptothorax curvispinosus* MAYR

Date	Queen	Worker	Male	Female	Pupa			Larva	Egg	Total in Colony
					w.	m.	f.			
3-28-42	1	360	.....	.....	.....	.....	.....	357	.....	727
	1	92	.....	.....	.....	.....	.....	144	.....	237
	1	134	.....	.....	.....	.....	.....	113	.....	248
4-19-42	1	75	.....	.....	.....	.....	.....	85	6	167
5-10-42	1	51	.....	.....	.....	.....	.....	175	26	253
5-17-42	.....	18	.....	.....	.....	.....	.....	90	.....	108
5-24-42	1	84	.....	.....	.....	.....	.....	89	71	245
	1	138	.....	.....	.....	.....	.....	78	153	370
	.....	61	.....	.....	.....	.....	.....	126	96	283

TABLE II—(Continued)

Date	Queen	Worker	Male	Female	Pupa			Larva	Egg	Total in Colony
					w.	m.	f.			
5-31-42	1 1	204 24	.....	.....	.....	.....	.....	169 27	167 24	541 76
6- 7-42	..... ..... 1	22 39 90	.....	.....	.....	.....	12 ..... 3	86 77 71	28 45 88	148 161 253
6-14-42	1 .....	168 42	.....	.....	..... 1	1 .....	16 22	257 62	141 6	584 133
6-21-42	1 1	41 38	.....	.....	24 .....	16 106	.....	89 44	37 89	208 278
6-27-42	1	84	.....	.....	1	3	62	192	86	429
6-28-42	.....	14	.....	.....	.....	26	2	16	6	64
7- 5-42	..... 1	53 7	35	11	..... 47	31	10	98 48	19 16	257 119
8-16-41	1 1 1 ..... ..... 1	125 124 31 41 14 121	.....	.....	49 42 10 7 ..... 7	.....	.....	108 137 31 76 17 66	31 4 23 15 ..... 194	314 308 96 139 31 389
9- 2-42	1 1	55 78	3	.....	11 21	.....	.....	136 104	33 28	239 232
9- 4-41	1 1	117 158	.....	.....	6 17	.....	.....	134 156	12 33	270 365
10-11-42	.....	87	.....	.....	.....	.....	.....	114	.....	201
10-20-41	1	54	.....	.....	.....	.....	.....	88	.....	143
11-17-41	..... .....	25 45	.....	.....	.....	.....	.....	101 41	.....	126 86
12-14-40	1 1	165 61	.....	.....	.....	.....	.....	79 52	.....	245 114

## SUMMARY

1. In order to make a quantitative study of populations of two ant species, 97 colonies of *Leptothorax longispinosus* and 38 colonies of *Leptothorax curvispinosus* were collected in an oak woods in Ashtabula Co., Ohio. All of these colonies were nesting in acorns. They were collected throughout the year in order to make a year-round study of fluctuations of total populations and of the various developmental stages.

## 2. Populations of Individuals in the Colony.

	<i>L. longispinosus</i>	<i>L. curvispinosus</i>
Average population per colony.....	135.9	235.0
Largest colony collected.....	419.0	727.0
Average number of workers per colony..	45.8	82.6
Largest number of workers per colony...	141.0	367.0
Proportion of workers to total population	1 to 3.0	1 to 2.8
Brood overwintered.....	larvae only	larvae only
Beginning of spring egg laying.....	mid May	mid April
Peak of egg production.....	August	August
End of egg laying season.....	mid Sept.	mid Sept.
Overwintered larvae began pupating...	first of June	first of June
Summer larvae all pupated by.....	mid Sept.	mid Sept.

3. *Populations of Nests in an Area*.—In the woods investigated almost the entire ant population nested in acorns. In a plotted area of 500 sq. ft., there were 58 acorn ant nests. These nests contained 8962 ants or 17.9 ants per sq. ft. There were 3180 workers or 6.4 workers per sq. ft. Thus each worker foraged for itself and 2 others of the colony. Of these 58 colonies, 41 were of *Leptothorax longispinosus*, 13 were of *Leptothorax curvispinosus*, and 4 were of other species of ants. There was an average of one ant colony for 9.5 acorns.

4. *Parasitism by Harpagoxenus americanus*.—Fifteen colonies of *L. longispinosus* were infested by the slave making ant *Harpagoxenus americanus*; thus 1 out of 6.5 were parasitized. No *Harpagoxenus* were found in *L. curvispinosus* colonies.

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# THE TYPES OF HESPERIOID GENERA. FURTHER ADDITIONS AND CORRECTIONS TO THE LINDSEY LIST, 1925<sup>1</sup>

HAROLD H. SHEPARD,

University of Minnesota,  
St. Paul, Minnesota

In 1925 A. W. Lindsey<sup>2</sup> published a catalog of 568 Hesperiid generic names (exclusive of *Battus* and *Frenati*, as well as four names listed as clerical errors) with data concerning genotype fixations. The present writer in 1931<sup>3</sup> added 25 names and called attention to several corrections made necessary by new information. In the decade following this second paper several workers have contributed important revisions of the Hesperiidae of the Indo-Australian and the African regions, and of Argentina on the South American continent. Recent intensive investigations pertaining to the publication dates of early works, especially the dates of Hübner's works by Hemming, have changed the standings of some of the earlier names. In the compilation of a new *Nomenclator Zoologicus* (1939), S. A. Neave added a number of early names that do not appear in Scudder's *Nomenclator Zoologicus* (1882). A few of these are names also in use for Hesperiid genera. For the latter Hemming has suggested new names. The status of the older generic names of holarctic butterflies up to 1863 has been reviewed by Hemming.<sup>4</sup> A total of 63 new names appears in the present list of additions to Hesperiid genera and their types.

According to Opinion 65 rendered in connection with the International Rules of Zoological Nomenclature, if an author designates a certain species as genotype, it is to be assumed that his determination of the species is correct. Hemming, however (note page 10 of Generic Names of Holarctic Butterflies), appears to have applied a different reasoning in some cases (as in *Spilothyrsus*). Fortunately a difference of interpretation here does not make for much confusion. With *malvae* as the type of *Spilothyrsus* the latter is a strict synonym of *Pyrgus* whereas with *alceae* as type *Spilothyrsus* falls to *Carcharodus*.

Although the new *Nomenclator Zoologicus* is of inestimable value in reducing the labor of checking for homonyms, the importance of specialized lists accompanied by genotype citations and related pertinent evidence remains. The intensive review of genotypes in all the various groups of insects would be a potent move toward the relatively stable nomenclature for which all zoologists long. To give some idea of the degree to which stability is being attained in the Hesperiid genera, the status of only eight generic names has changed significantly since 1925 out of the 83 listed by Lindsey as being proposed before 1860.

<sup>1</sup>Paper No. 1946, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul.

<sup>2</sup>Lindsey, Ann. Ent. Soc. Amer., 18: 75-106, 1925.

<sup>3</sup>Shepard, Ann. Ent. Soc. Amer., 24: 173-176, 1931.

<sup>4</sup>Hemming, Generic Names of Holarctic Butterflies, British Museum, 1934.

Naturally the older names are the harder ones to stabilize. At the same time they provide the more conspicuous examples of instability because they frequently apply to well known insects. It is gratifying that wherever possible most workers, in citing genotypes, make selections which will cause the least confusion or even result in no change whatever.

The form of the previous papers in this series has been followed for the sake of uniformity. Preoccupied names are marked †. It appears helpful to repeat the terms used by Lindsey to designate the various kinds of genotype fixation:

*Orthotype*—a type designated in the original generic diagnosis.

*Haplotype*—a type by virtue of being the single included species.

*Logotype*—a type designated subsequent to the original diagnosis.

*Diatype*—a type of a genus substituted for a homonym.

*Pseudotype*—a type designated wrongly.

#### (Abantiades)

1894, Fairmaire, Ann. Soc. Ent. Belg., 38: 395. Fairmaire listed several generic changes, including "*Abantis* (Lépidoptères) = *Abantiades*." Apparently he meant that *Abantis* Fairmaire, 1892, Coleoptera, Tenebrionidae, being preoccupied in the Lepidoptera (Hopffer, 1855), should be replaced by *Abantiades* Fairmaire, 1894, new name (see Coleopt. Catalogus, 18: 341). Shepard (Lepid. Catalogus, (pt. 69): 328, 1935) was misled by Fairmaire's lack of explanation. He was followed in this by Evans (Cat. Afric. Hesp. 51, 1937). *Abantiades* should no longer be included in lists of Hesperiid generic names.

**Acada** Orthotype *Pamphila biseriata* Mab.

1937, Evans, Cat. Afric. Hesp., 108-109.

**Adlerodea** Orthotype *Adlerodea modesta* Hayw.

1940, Hayward, Anales Sociedad Cientif. Argentina, 130: 75.

**Aecas** Diatype *Papilio aecas* Stoll

1939, Hemming, Proc. Roy. Ent. Soc. London, (B) 8: 137. To replace *Flaccilla* Godman, 1901, preoccupied.

**Alenia** Orthotype *Pyrgus sandaster* Trim.

1935, Evans in Hale Carpenter, Trans. Roy. Ent. Soc. London, 83: 409.

**Ametron** Orthotype *Ametron subviridis* Hayw.

1940, Hayward, Anales Sociedad Cientif. Argentina, 130: 85.

**Andinus** Orthotype *Andinus venustus* Hayw.

1940, Hayward, Rev. Soc. Ent. Argentina, 10: 284.

**Anisynthoides** Orthotype *Cyclopides argenteo-ornatus* Hew.

1932, Waterhouse, Austral. Zool., 7: 198, 200.

**Ankola** Orthotype *Osmodes* (?) *fan* Holl.

1937, Evans, Cat. Afric. Hesp., 106-107.

**Antigonus** Orthotype *Urbanus erosus* Hübner.

1819, Hübner, Verz. bek. Schmett., (7): 108. The only described species included was *erosus* Hübner; *ustus* (Hübner) Geyer, 1832, was at that time only a manuscript name, as pointed out by Hemming (1934).

**Arrhenella** Orthotype *Pamphila marnas* Feld.

1937, Waterhouse, Proc. Linn. Soc. New So. Wales, 62: 122. To replace *Arrhenes* as used by Evans (1926, 1932, 1934) and by Waterhouse (1932).

#### **Arrhenes**

1904, Mabille in Wytzman, Gen. Ins., 17b: 142. "*Arrhenes*, Mabille in litt." given as a synonym of *Ocybadistes* Heron.

1926, Evans, Jour. Bombay Nat. Hist. Soc., 31: 57. Said "5 or more species," but named none.

1932, Waterhouse, Austral. Zool., 7: 200. Type cited as *marnas* Feld.

1934, Evans, Entomol., 67: 206. Also cited *marnas*.

1937, Waterhouse, Proc. Linn. Soc. New So. Wales, 62: 122. Pointed out that *Arrhenes* was first mentioned as a manuscript synonym, and that it can only be considered as a synonym of *Ocybadistes* Mabille (not Heron); see *Arrhenella*.



- Astycus** Logotype *Papilio tages* Linn.  
 1822, Hübner, Syst. Alph. Verz., 1, 3, 5, 6, 8-10. Included *tages* and 21 other European species, but not *augias* (according to Hemming).  
 1825, Hübner, Cat. Lép. Coll. Franck, 85. Included *augias* (according to Scudder, 1875).  
 1875, Scudder, Proc. Amer. Acad. Arts and Sci., 10: 122. Cited *augias* as type.  
 1933, Hemming, Entomol., 66: 200. Cited *tages* as type.
- Ateleomorpha** Logotype *Hesperia onopordi* Ramb.  
 1926, Warren, Trans. Roy. Ent. Soc. London, 74: 19, 87, 164.  
 1934, Hemming, Stylops, 3: 143. Cited *onopordi* as type. (see *Teleomorpha*).
- Aurina** Orthotype *Aurina dida* Evans  
 1937, Evans, Cat. Afric. Hesp., 26.
- Baorynnis** Orthotype *Pamphila amalia* Semper  
 1932, Waterhouse, Austral. Zool., 7: 201.
- Brusa** Orthotype *Parnara saxicola* Neave  
 1937, Evans, Cat. Afric. Hesp., 173. On plate 7 as *Bruasa* in error.
- Caicella** Diatype *Eudamus caicus* H.-S.  
 1934, Hemming, Stylops, 3: 144. To replace *Phoedrus* Godman and Salvin, 1894, preoccupied.
- Carcharodus** Logotype *Papilio alceae* Esp. (= *fritillarius* Poda, 1761).  
 1819, Hubner, Verz. bek. Schmett., (7): 110. Included three species: *lavatherae* [sic] (as No. 1189), *althaeae* (as No. 1190), and "*C. Malvae* Schiff. Verz. Pap. A. 1. Hübner, Pap. 450. 451. *Alceae* Esp. Pap. 51.3." (as No. 1191). On page 109, Hübner had already placed *malvae* Linn. in the genus *Pyrgus*.  
 1879, Plötz, Ent. Zeitg. Stettin, 40: 179. Cited *alceae* as type.  
 1893, Watson, Proc. Zool. Soc. London, 44, 67. Cited *lavaterae* as type.  
 1934, Hemming, Gen. Names Holarctic Butt., 164. Believed that *alceae* (= *fritillarius*) should be the type.
- Carterocephalus** Logotype *Papilio paniscus* Fab. (= *palaemon* Pall.)  
 1852, Lederer, Verh. zool.-bot. Ges. Wien., 2: 26, 49. Included (p. 26) *paniscus* Fab. (= *palaemon* Pall.), *sylvius* Kn., and *argyrostigma* Ev.; also (p. 49) proposed as a new name for *Steropes* Boisduval. The latter usage by Lederer evidently referred to *Steropes* of Boisduval (1836) which contained *paniscus*; *Steropes* Boisduval (1832) was erected for *picta*, *ornata* and *jacchus* (see Hemming, 1934). However, because the first valid use of *Carterocephalus* is on page 26, the identity of *Steropes* Boisduval does not affect the case. (Although the generic name *Steropes* Boisduval is a homonym, Lederer discarded it not for this reason but because it contained the specific name *steropes*, a case of tautonymy which was at that time considered undesirable but which is not discouraged by the present International Rules.)  
 1875, Scudder, Proc. Amer. Acad. Arts and Sci., 10: 270. Cited *paniscus* Fab. as type.
- †**Choerephon** Orthotype *Pamphila citrus* Mab.  
 1900, Godman, Biol. Centr.-Amer., Rhop., 2: 474. Preoccupied by *Choerephon* Dobson, 1874, Mamm.; see *Yvretta*.
- Chitralia** Diatype *Elwesia lesliei* Evans  
 1932, Evans, Identif. Indian Butt., 2d ed., 307, 357. Erected to replace *Elwesia* Evans, preoccupied.
- Cobaloides** Orthotype *Cobaloides argus* Hayw.  
 1938, Hayward, Anales Sociedad Cientif. Argentina, 126: 448.
- Coeliades** Logotype *Papilio forestan* Stoll  
 1818, Hübner, Zuträge Exot. Schmett., 1: 31. Contains only *laminatus* and *forestan* (according to Hemming).  
 1819, Hübner, Verz. bek. Schmett., (7): 106. Contains *forestan*, *dubius* and *chromus*.  
 1875, Scudder, Proc. Amer. Acad. Arts and Sci., 10: 145. Cited *dubius* as type.  
 1935, Hemming, Trans. Roy. Ent. Soc. London, 83: 436. Fixed *forestan* Stoll as type; thus *Rhopalocampa* with the same type falls to *Coeliades*. (See *Dubietta*).
- Cretseus**  
 1852, Westwood in Doubleday and Westwood, Gen. Diurn. Lepid., 2: 511. Given as of Hübner in a list of generic synonyms under "*Gonioloba* Westw."
- †**Cretseus** Orthotype *Hesperia cyrina* Hew.  
 1895, de Nicéville, Jour. Bombay Nat. Hist. Soc., 9: 385. Preoccupied by *Cretseus* Westwood, 1852, Lepid., Hesp.; see *Cyrina*.

- Croitana** Orthotype *Cyclopides croites* Hew.  
1932, Waterhouse, Austral. Zool., 7: 199, 200.
- Ctenoptilon**  
1903, Mabille in Wytsman, Gen. Ins., Hesp., 75. Misspelling of *Ctenoptilum* de Nicév., 1890; repeated in Seitz, vols. 1 and 9.
- Cyclosma** Haplotype *Cyclosma abdonides* Draudt  
1924, Draudt in Seitz, Macrolepid. World, 5: 978.
- Cydrus**  
1820, Billberg, Enum. Ins., 81. Dalman MS; an Hesperoid name, according to S. A. Neave.
- †**Cydrus** Haplotype *Cydrus naevolus* Godman  
1900, Godman, Biol. Centr.-Amer., Rhop., 2: 512. Preoccupied by *Cydrus* Billb., 1820, Lepid., Hesp.; see *Naevolus*.
- Cyrina** Diatype *Hesperia cyrina* Hew.  
1939, Hemming, Proc. Roy. Ent. Soc. London, (B) 8: 39. To replace *Creteus* de Nicév., 1895, preoccupied.
- Dardarina** Orthotype *Cyclopides dardaris* Hew.  
1937, Evans, Revista Ent., 7: 88-89.
- Dubiella** Orthotype *Papilio dubius* Stoll  
1936, Evans, Proc. Roy. Ent. Soc. London, (B) 5: 55. New name for *Coeliades* auct.
- †**Elwesia** Orthotype *Elwesia lesliei* Evans  
1926, Evans, Jour. Bombay Nat. Hist. Soc., 31: 53, 429. Preoccupied by *Elwesia* Hampson, 1894, Lepid., Noctuidae; see *Chitralka*.
- Felicena** Orthotype *Thymele dirpha* Bois.  
1932, Waterhouse, Austral. Zool., 7: 199, 200.
- †**Flaccilla** Orthotype *Papilio aecas* Stoll  
1901, Godman, Biol. Centr.-Amer. Rhop., 2: 593. Preoccupied by *Flacilla* Koken, 1896, Moll.; see *Aecas*.
- Fresna** Orthotype *Hesperia nelopha* Hew.  
1937, Evans, Cat. Afric. Hesp., 164-166.
- Fulda** Orthotype *Hesperia coroller* Bois.  
1937, Evans, Cat. Afric. Hesp., 86-88.
- †**Gastrochaeta** Haplotype *Gastrochaeta mabiliei* Holl.  
1894, Holland, Ent. News, 5: 28. Preoccupied by *Gastrochoeta* Dujardin, 1840, Prot.; see *Meza*.
- Gretna** Orthotype *Hesperia cylinda* Hew.  
1937, Evans, Cat. Afric. Hesp., 149-151.
- Hemitelemorpha** Logotype *Papilio malvae* Linn.  
1926, Warren, Trans. Ent. Soc. London, 74: 19, 72, 163.  
1934, Hemming, Stylops, 3: 143. Cited *malvae* as type. (See *Teleomorpha*.)
- Heteropterus** Haplotype *Papilio morpheus* Pall.  
1806, Duméril, Zool. Anal., 271. No species given.  
1823, Duméril, Consid. gén. Classe Ins., 222, pl. 41 (nec 42). Only *morpheus* indicated.  
1870, Kirby, Jour. Linn. Soc. London, (Zool.) 10: 500. First citation of *morpheus* as genotype, as pointed out by Hemming.
- Hovala** Orthotype *Cyclopides pardalina* Butl.  
1937, Evans, Cat. Afric. Hesp., 64-66.
- Iliana** Orthotype *Iliana romulus* Bell  
1937, Bell, Amer. Mus. Novit., (914): 8.
- †**Ismene** Haplotype *Ismene oedipodea* Swains.  
1820, Swainson, Zool. Illust., 1, pl. 16. Preoccupied by *Ismene* Savigny, 1816, Lepid., Pyralid. *Oedipodea*, the only included species, being congeneric with *vasutana* Moore, the type of *Burara* Swinhoe, the latter generic name replaces *Ismene* of Swainson. Evans (Entomol. 67: 33, 1934) supplanted the subfamily name *Ismeninae* by *Rhopalocampinae*; however, following the action of Hemming (Trans. R. Ent. Soc. Lond., 83: 436, 1935) in fixing the type of *Coeliades* Hübner (1818), *Coeliadinae* was suggested by Evans (Cat. Afric. Hesp., 9, 1937) as the appropriate name (see *Coeliades*).
- Kobrona** Orthotype *Platingia kobros* Plötz  
1935, Evans, Entomol., 68: 66.
- Leona** Orthotype *Hesperia leonora* Plötz  
1937, Evans, Cat. Africa. Hesp., 153-157.

- Lepella** Orthotype *Hesperia lepeletier* Latr.  
1937, Evans, Cat. Afric. Hesp., 76.
- Limochroes**  
1902, Dyar, Bull. U. S. Nat. Mus., 52: 55. An unfortunate misspelling of *Limochores* Scudder which was copied frequently from this list of North American lepidoptera for some years.
- Melphina** Orthotype *Parnara melphis* Holl.  
1937, Evans, Cat. Afric. Hesp., 162-164.
- Metisella** Diatype *Papilio metis* Linn.  
1934, Hemming, Stylops, 3: 99. To replace *Cyclopides* auct. and *watsonia* Tutt, 1906, preoccupied.
- Meza** Diatype *Gastrochaeta mabiliei* Holl.  
1939, Hemming, Proc. Roy. Ent. Soc. London, (B) 8: 39. To replace *Gastrochaeta* Holl., 1894, preoccupied. In error Hemming gave *Hesperia meza* Hew., 1877, as type; perhaps because Evans (Cat. Afric. Hesp., 124, 1937) placed it first in his treatment of *Gastrochaeta* species.
- Milena** Orthotype *Parnara plebeia* de Nicév.  
1912, Evans, Jour. Bombay Nat. Hist. Soc., 21: 559, 1005. On page 559 *Milena* is listed as a new subgenus of *Parnara*; on page 1005, "*Plebeia*, the only *Parnara* with a tuft of hair on the underside of the forewing deserves to be placed in a separate subgenus for which I propose the name *Milena*."  
1925, Lindsey, Ann. Ent. Soc. Amer., 18: 92. Concluded the name is a *nomen nudum* to be sunk in *Parnara*, but apparently the statement on p. 1005 was overlooked.  
1937, Evans, Cat. Afric. Hesp., 175. Stated genotype was fixed by author as *Parnara plebeia* de Nicév.
- Mimoniades** Haplotype *Mimoniades ocyalus* Hübn.  
1823, Hübner, Zuträge, Exot. Schmett., 2: 27. One species, *ocyalus* Hübn.  
1925, Lindsey, Ann. Ent. Soc. Amer., 18: 92. "Haplotype *Erycides iphinus* Latr."  
1934, Bell, Jour. New York Ent. Soc., 42: 393. Pointed out that *iphinus* Latr. was determined by Mabilie (1909) not to be synonymous with *ocyalus* Hübn.
- Miraja** Orthotype *Trapezites varians* Oberth.  
1937, Evans, Cat. Afric. Hesp., 133-136.
- Moltana** Orthotype *Proleides fiara* Butl.  
1937, Evans, Cat. Afric. Hesp., 139.
- Monza** Orthotype *Goniloba cretacea* Snell.  
1937, Evans, Cat. Afric. Hesp., 160-162.
- Mopala** Orthotype *Ismene* (?) *orma* Plötz  
1937, Evans, Cat. Afric. Hesp., 148.
- Naevolus** Diatype *Cydrus naevolus* Godm.  
1939, Hemming, Proc. Roy. Ent. Soc. London, (B) 8: 39. To replace *Cydrus* Godm., 1900, preoccupied.
- Neoxeniades** Orthotype *Neoxeniades musarion* Hayw.  
1938, Hayward, Revista Ent., 9: 372.
- +Nicevillea** Orthotype *Pamphila gola* Moore  
1926, Evans, Jour. Bombay Nat. Hist. Soc., 31: 57. Preoccupied by *Nicevillea* Hampson, 1895, Lepid., Noctuid.; see *Oriens*.
- Noctuana** Orthotype *Helias noctua* Feld.  
1937, Bell, Amer. Mus. Novit., (914): 7.
- Oriens** Diatype *Pamphila gola* Moore  
1932, Evans, Identif. Indian Butt., 2d ed., 312, 399. To replace *Nicevillea* Evans, 1926, preoccupied.
- Panoquina** Diatype *Hesperia panoquin* Scudd.  
1934, Hemming, Entomol., 67: 38. To replace *Prenes* Scudder, 1872, preoccupied.
- Pasma** Orthotype *Hesperilla tasmanicus* Misk.  
1932, Waterhouse, Austral. Zool., 7: 198, 200.
- Pedesta** Diatype *Isoleinon masuriensis* Moore  
1934, Hemming, Entomol., 67: 38. To replace *Pedestes* Watson, 1893, preoccupied.

- †**Pedestes** Orthotype *Isoleinon masuriensis* Moore  
1893, Watson, Proc. Zool. Soc. London, 81. Preoccupied by *Pedestes* Gray,  
1842, Mamm.; see *Pedesta*.
- †**Perimeles** Haplotype *Hesperia remus* Fabr.  
1900, Godman, Biol. Centr.-Amer., Rhop., 2: 542. Preoccupied by *Perimeles*  
Lenz, 1831, Mamm.; see *Remella*.
- Perrotia** Logotype *Perrotia albiplaga* Oberth.  
1916, Oberthür, Etud. Léop. Comp., 11: 240. Neave (Nomencl. Zool. 1939)  
gave the earliest date as 1922.  
1937, Evans, Cat. Afric. Hesp., 136-138. Designated *albiplaga* as type.
- †**Phoedinus** Logotype *Eudamus caicus* H.-S.  
1894, Godman and Salvin, Biol. Centr.-Amer., Rhop., 2: 335.  
1921, Lindsey, Hesp. No. Amer., 35. Cited *caicus* as type. Preoccupied by  
*Phaedinus* Dupont, 1834, Col.; see *Caicella*.
- Pintara** Orthotype *Plesioneura pinwilli* Butl.  
1932, Evans, Identif. Indian Butt., 305, 338.
- †**Prenes** Orthotype *Hesperia panoquin* Scudd.  
1872, Scudder, Syst. Rev. Amer. Butt., 60 (Ann. Rep. Peabody Acad. Sci., 4,  
1871: 81). Preoccupied by *Prenes* Gistl., 1848, Pisces; see *Panoquina*.
- Prusiana** Orthotype *Pamphila prusias* Feld.  
1937, Evans, Entomol., 70: 38.
- Pyrgus** Logotype *Papilio malvae* Linn.  
1819, Hübner, Verz. bek. Schmett., (7): 109. *Syrichthus*, *alveolus* (= *malvae*),  
and others.  
1841, Westwood in Humphreys and Westwood, Brit. Butt. and their Transform.,  
(1st ed.): 120. Selected *malvae* Linn. as type. This citation (Hemming,  
Entomol., 67: 112, 1934) takes precedence over that of *syrichthus* by  
Butler, 1870.
- Pyrrhopyge** Logotype *Papilio bixae* Linn.  
1819, Hübner, Verz. bek. Schmett., (7): 103. For *bixae* Linn., *hyperici* Hübn.  
MS, *phidias* Linn., and *amyclas* Cram.  
1872, Scudder, Syst. Rev. Amer. Butt., 46 (Ann. Rep. Peabody Acad. Sci.,  
1871, 4: 67). *Bixae* cited as type of "*Pyrrhopyga*."  
1875, Scudder, Proc. Amer. Acad. Arts and Sci., 10: 261. Pseudotype *hyperici*.  
1925, Lindsey, Ann. Ent. Soc. Amer., 18: 99. Corroborates Scudder's first  
fixation.  
1940, Evans, Jour. New York Ent. Soc., 48: 405-411. Pointed out that the  
Aurivillius determination (1882) of *bixae* is not represented by Clerck's  
figure but by the Merian figure of a Surinam insect. A change in the  
status of the generic name is avoided by this finding.
- Remella** Diatype *Hesperia remus* Fabr.  
1939, Hemming, Proc. Roy. Ent. Soc. London, (B) 9: 39. To replace *Perimeles*  
Godman, 1900, preoccupied.
- Schausana** Orthotype *Hesperia* (?) *altama* Schaus  
1938, Bell, Amer. Mus. Novit., (1013): 7.
- Spilothyrus** Logotype *Papilio malvae* Linn.  
1835, Duponchel in Godart, Hist. Nat. Lépid. France, Suppl. 1: 415. For  
*malvae*, *althea* (sic), and *lavaterae*, according to Scudder who refers  
Duponchel's *malvae* to *alceae*, as also does Hemming. The latter writer says  
Duponchel gave no author's names for the species he cited.  
1893, Watson, Proc. Zool. Soc. London, 67. Cited *alceae* as type, doubtless  
because of Scudder's statement.  
1925, Lindsey, Ann. Ent. Soc. Amer., 18: 101. Regarded *malvae* Linn. as type.  
1934, Hemming, Gen. Names Hol. Butt., 164. Considered Watson's selection  
of *alceae* to be the valid one. It is not profitable here, however, to argue  
the point because whichever type is the valid one (*malvae* or *alceae*), *Spilo-*  
*thyrus* is a strict synonym of either *Pyrgus* or *Carcharodus*.
- Suniana** Orthotype *Pamphila lascivia* Rosenst.  
1934, Evans, Entomol., 67: 151.
- (**Synemon**)  
1846, Doubleday in Stokes, Discov. in Australia, 1: 515. Refers to a moth;  
listed in Lepid. Catalogus (part 83): 107 through an error.

- Syrictus** Logotype *Papilio sertorius* Hfag.  
 1834, Boisduval, Icon. Hist. Lépid. Europe, 1: 230, including *malvae*, *therapne*, *proto*, *sao*, and many others. *Sao* now goes under the name *sertorius*.  
 1879, Plötz, Ent. Zeitg. Stettin, 40: 179. Type cited as *sao*. In Boisduval's original, *sao* was treated as a species quite separate from *therapne*, contrary to the impression one gains from Scudder (1875)!  
 1897, Elwes and Edwards, Trans. Zool. Soc. London, 14: 153. Cited *proto* as type.  
 1934, Hemming, Gen. Names Hol. Butt., 165. Claimed Plötz selected *malvae* although that author called it *sao*.
- Tabraca** Haplotype *Sarangesa aurimargo* Holl.  
 1896, Holland, Proc. Zool. Soc. London, 10. (Mabille i. l.).
- Talides** Logotype *Papilio sergestus* Cram.  
 1819, Hübner, Verz. bek. Schmett., (7): 106. Included *sinois* Hübn. (= *sergestus*), *athenion* Hübn. (Samml. exot. Schmett., 2, pl. (148).)  
 1870, Butler, Ent. Mon. Mag., 7: 93. Selected *athenion* as type.  
 1875, Scudder, Proc. Amer. Acad. Arts and Sci., 10: 275. Claimed that *sergestus* had become type by elimination prior to 1870. The status of *Talides*, however, must depend upon whether *athenion* was already published or was still a manuscript name at the appearance of signature 7 of the Verzeichniss.  
 1937, Hemming, Hübner, 1: 409. Plate (148) of the Sammlung, vol. 2, is given the date 1825.
- Teleomorpha** Logotype *Papilio carthami* Hübn.  
 1926, Warren, Trans. Ent. Soc. London, 74: 18, 46, 163. *Teleomorpha*, *Hemiteleomorpha* and *Ateleomorpha* were erected as subgenera of *Hesperia* auct. (*Pyrgus*), but without type designations.  
 1934, Hemming, Stylops, 3: 143. Cited *carthami* as type.
- Thanaos** Logotype *Papilio tages* Linn.  
 1834, Boisduval, Icon. Hist. Lépid. Europe, 1: 240.  
 1840, Blanchard, Hist. Nat. Ins., 3: 469. Cited *tages* as type, according to Hemming, 1934. This citation antedates that of *juvenalis* by Butler, 1870.
- Thanatos** Haplotype *Papilio tages* Linn.  
 1858, [Dunning and Pickard], Accentuated List Brit. Lepid., 6. *Tages* Linn. is the only included species (Hemming, 1934.)
- Tirynthoides** Orthotype *Tirynthoides eclates* Bell  
 1940, Bell, Amer. Mus. Novit., (1064): 1.
- Tsitana** Orthotype *Cyclopides tsita* Trim.  
 1937, Evans, Cat. Afric. Hesp., 75.
- Urbanus** Logotype *Papilio proteus* Linn.  
 1806, Hübner, Tentamen; invalidated by Opinion 97 of the International Commission. The single included species was *malvae* Linn.  
 1806-07, Hübner, Samml. exot. Schmett., 1, pl. (149)-(160). Used *Urbanus* for *proteus* Linn., and others.  
 1875, Scudder, Proc. Amer. Acad. Arts and Sci., 10: 287. Cited as type the sole species included in the Tentamen but he called it *alceae* Esp. (see *Carcharodus*).  
 1922, Barnes and Lindsey, Ann. Ent. Soc. Amer., 15: 94. Considered *malvae* Linn. the type.  
 1933, Hemming, Entomol., 66: 200. Cited *proteus* Linn. as type on the basis of the first valid publication of *Urbanus* in the Sammlung. The names *Goniurus* Hübn. and *Eudamus* Swain. become therefore synonyms of *Urbanus*.
- Vistigma** Orthotype *Vistigma xanthobasis* Hayw.  
 1938, Hayward, Anales Sociedad Cientif. Argentina, 126: 452.
- Yvretta** Diatype *Pamphila citrus* Mab.  
 1935, Hemming, Stylops, 4: 3. To replace *Chaerophon* Godm., 1900, preoccupied.
- Zenonia** Orthotype *Pamphila seno* Trim.  
 1935, Evans in Hale Carpenter, Trans. Roy. Ent. Soc. London, 83: 405. Genotype as *Pamphila senonia* is a typographical error.
- Zinalda** Orthotype *Parnara nascentis* Leech  
 1937, Evans, Entomol., 70: 64.

## TWO NEW SPECIES OF AMERICAN CERATOPOGONIDAE

### (Diptera)

O. A. JOHANNSEN,  
Cornell University,  
Ithaca, New York

#### ***Stilobezzia uncinata* n. sp.**

♀. Antennae slender, elongate, each segment with a few stout bristle-like hairs in addition to the setulae, resembling that of *Ceratobezzia* (fig. 20, p. 767). Thorax arched and with short, erect, scattered, discal bristles in addition to the decumbent hairs, as in *Dicrobezzia* (fig. 23, p. 767). Femora and fifth tarsal segments without stout ventral spines; all claws strong, very large, much curved, without basal tooth, one claw on each foot somewhat shorter than the other (fig. 21, p. 767); fourth tarsal segment cordate. Wing (fig. 12, p. 765) with a single radial cell anterior to the posterior branch of the radius; costa produced beyond the tip of this vein; media petiolate; microtrichia visible under a magnification of 300 diameters.

Shining black, including head, thorax, abdomen, coxae, and fore legs. Antennae and palpi black; middle and hind legs brownish black, their tarsi brown. Halteres reddish brown. Wings hyaline, venation as figured (fig. 12, p. 765). Length 1.4 mm.; wing 1.2 mm. A single female specimen collected by Dr. J. C. Bradley at La Place (near Tuskegee), Alabama, June 9, 1917. Holotype in the Cornell University collection.

This species differs from all members of the genus *Stilobezzia* as now restricted in having the costa produced beyond the tip of the second radial branch and in the structure of the tarsal claws, and differs from most of the species in having but one anterior radial cell. Following the present practice of creating genera on minor characters the erection of a new genus or at least a subgenus for it might have been justified.

#### ***Ceratobezzia flavida* n. sp.**

♀. Occiput of head, scape, the first, and the bases of the next three or four flagellar antennal segments, the thorax, legs, venter, the very narrow bases of abdominal tergites one to three, and the basal third of each of the remaining tergites, light amber yellow. The front, mouth-parts in large part, a longitudinal blotch on the thorax at each wing base, and the first three abdominal tergites, brown. Posterior two-thirds of each of the remaining tergites pale brown. Wing veins and halteres pale yellow.

Antennae slender, relative lengths of segments as figured (fig. 20, p. 767), the hairs sparse, short, stout, and bristle-like, but specialized sensillae apparently lacking. Thorax only slightly arched (fig. 22, p. 767), anterior margin of mesonotum with a sharp, strong, semi-erect tubercle which is over twice as long as width at base. Legs

slender, distinctly hairy, but neither femora nor fifth tarsal segments are armed with spines; third tarsal segments not twice as long as broad, hind tarsal segments 3 to 5 combined, shorter than the second segment; fourth segment on all feet strongly cordate, the lobes not ending in a spine; the fifth on all feet with small, equal, barbed claws; empodium vestigial. Wing venation about as in *Bezzia*, microtrichia visible under a magnification of  $\times 700$ , macrotrichia lacking. Costa not produced beyond tip of posterior branch of radius and ending 0.08 of wing length from the apex; second branch of radius not four times as long as the first; r-m crossvein nearly perpendicular, slightly longer than the first section of the anterior branch of the media, this branch ending behind the apex of the wing; cubitus forks slightly proximad of base of the second branch of the media. Abdomen elongate, slender, twice as long as the remainder of the body.

Length 3.3 mm.; wing 2.6 mm.; antenna 1.5 mm.

A single specimen collected by H. S. Parish in Bertina, British Guiana, Dec. 27, 1912. Holotype in the Cornell University Collection.

This species differs from the genotype, *C. fallax* K. (1917a, p. 326) in color, in having unmodified fifth tarsal segments on the fore feet, and in having claws of all feet small and equal.

INSECTOS DO BRASIL, VOL. 4, PANORPATOS, SUCTORIOS (PULGAS), NEUROPTEROS, TRICOPTEROS, by A. DA COSTA LIMA, 1943. Chaps. 24-27, 141 pages, 96 figs. 8 vo.,  $6\frac{1}{4} \times 9$  in. Published by the ESCOLA NACIONAL DE AGRONOMICA. Avenida Pasteur 404, Rio de Janeiro, Brazil.

We are pleased to see the fourth volume of this important work on the insects of Brazil. It is equal to or is even better worked out than the three preceding volumes. Pages 1-15 are devoted to the Order Panorpatæ (Mecoptera); 17-71 to the Order Suctoria (Fleas); 73-108 to the Neuroptera and 109-141 to the Trichoptera.

As with the general plan as used in the preceding volumes the present section deals with the general characters of each group with ample excellent illustrations, and at the end of each ordinal discussion gives a bibliography of works covering that order for Brazil. It is the most comprehensive work we have had as yet on the insects of a South American country by one who has spent his life in intensive survey of them on the spot.

Brazil is athwart the great valley of the Amazon which is a very recent area geologically. The present volume in its review of the Neuroptera tends to reflect the modernness of the Amazonian fauna. Eventually when the headwaters in the older and much higher hinterlands are explored and particularly the tableland of southeast Brazil, there will be found many very primitive insects which will rate third in primitiveness to those of South Africa and Australia. Because of some close connection with the Australian fauna the insects of Chile appear to have many such primitives. The Guiana highlands are another area affording many primitive species. During the early Tertiary the faunas of South America indicate that instead of a continent the area was occupied by three great island masses, the highlands of southeastern Brazil, the Guiana highlands and the rising Cordellera. The Amazon Valley arose and connected these at a late date. At a still later date Panama arose and gave a path between Central and South America. Because of accessibility the first faunas well covered by collectors are those of the Amazon Valley and the coastal regions, both in the most recent fauna. The work, *Insectos do Brasil*, of course deals properly with the widespread and common forms primarily, as it is an introductory work. These forms tend to be recent. They are common and widespread because of their higher evolution.—C. H. K.

# A GENERIC SYNOPSIS OF THE CERATOPOGONIDAE (HELEIDAE) OF THE AMERICAS, A BIBLIOGRAPHY, AND A LIST OF THE NORTH AMERICAN SPECIES

O. A. JOHANNSEN,

Cornell University,  
Ithaca, New York

This paper deals with a group of insects which until recently has been considered a subfamily of the Chironomidae. The group is rather compact and this led Malloch (1915a) to propose the separation of it from the Chironomidae as a distinct family. A basic work on this family was published many years ago by Winnertz (1852), and since then a number of more or less comprehensive papers with synoptic tables have appeared, among them, those of Malloch (1915a), Goetghebuer (1920, 1933, 1934), Kieffer (1925a, 1926), Edwards (1926), Johannsen (1931), and Macfie (1940a). The works by Kieffer and Macfie include the genera of the world. The fact that some of the members of the family are blood suckers has in recent years aroused renewed interest in them with the result that a number of entomologists in different parts of the world are now engaged in a study of the species.

The family may be characterized as follows:

Head rounded behind; mandibles well developed and toothed in both sexes; blade of the maxilla present; third (or rarely fourth) segment of the palpus with sensory organ (fig. 32). Scape of antenna small and usually more or less hidden, the pedicel large and globular, the flagellum, with rare exceptions, with 13 segments in both sexes, the last three or four in the male lengthened, and the last five (six in *Pterobosca*) of the female differing somewhat in character from the others (figs. 18-20).

Pronotum hidden between the head and the scutum. The scutum in some cases with a minute stout spine on the anterior margin. Scutellum usually with bristles; postnotum rounded, without median furrow or keel. The membranous area of the pleura (anepisternal cleft) rather small, not triangular. Mesosternum (sternopleurite) not prominent, reaching only a little below the tip of the front coxae. Abdomen often with a pair of impressed areas, and in some species with eversible abdominal glands in the female. Spermathecae (fig. 46) strongly sclerotized, one to three in number.

In the male the ninth and anal segments and their appendages comprise the hypopygium. The ninth tergite and sternite are in some cases of characteristic form; the anal segment often with a pair of setigerous tubercles. The appendages consist of a pair of forceps the limbs of which are made up of a side-piece (basistyle) and a clasper (dististyle), an intromittant organ (the aedeagus), and the inner processes. The inner processes are the structures which of late years have been designated as *harpes* or *parameres* in this family.



Since both of these terms have been used in a different sense in other families of insects (see Christophers, 1922; Snodgrass, 1941) for the present the non-committal term of inner *processes* is used in this article (Plate III).

Legs moderately short, hind pair longest; hind tibia with a double comb at the tip; empodium present or absent, pulvilli absent. Wings usually superimposed over the back while at rest; two radial branches reach the costal margin; media forked except in *Leptoconops* (fig. 33) and *Brachypogon* (fig. 9). Alula scarcely indicated, sometimes fringed; squama small, sometimes with a tuft of hairs but never with a complete fringe.

Based chiefly on the structure of the mouth parts and the pharyngeal skeleton, Mayer (1934) divided the immature stages of this family into groups, each with one or more genera, as follows:

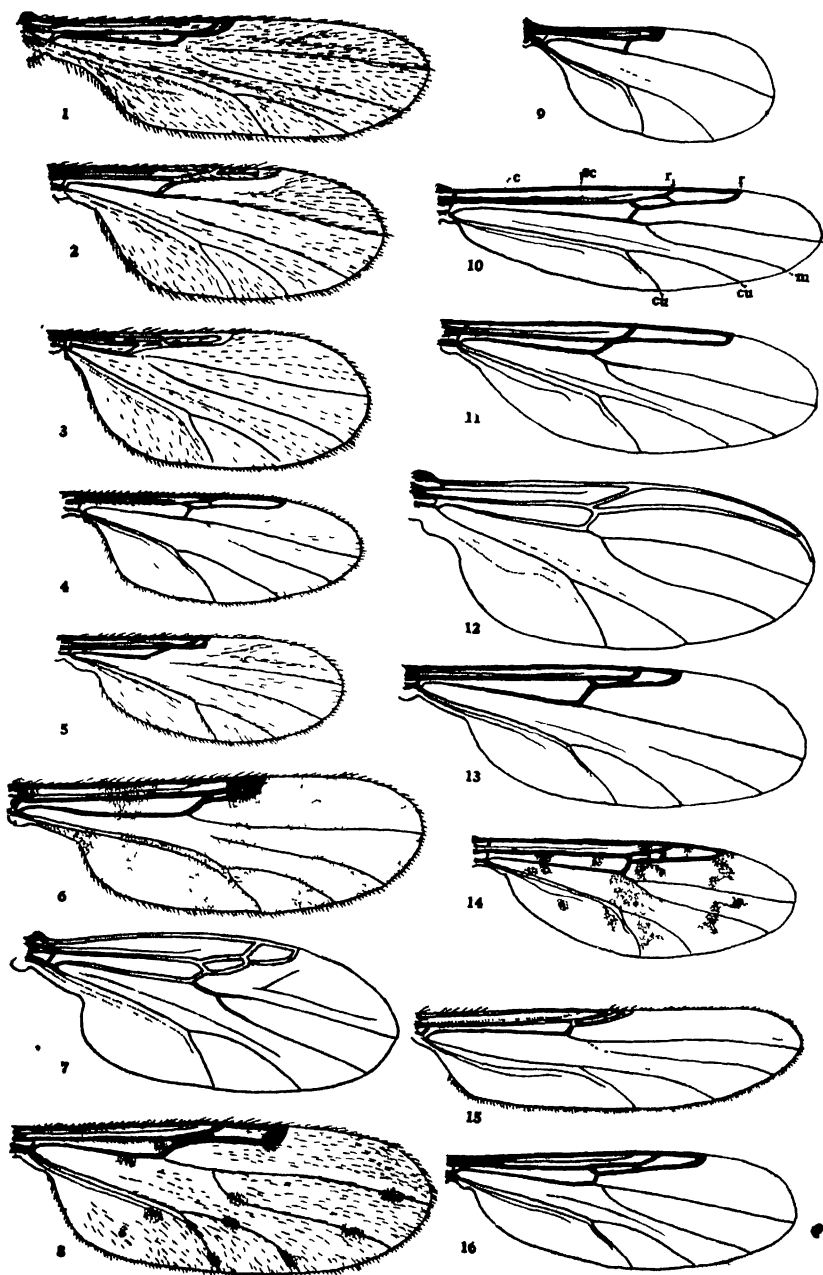
Groups *Leptoconops*, *Forcipomyia*, *Dasyhelea*, *Culicoides*, *Stilobezzia*, and *Palpomyia*. (See Thomsen, 1937).

The arrangement into groups by Macfie (1940a) on the basis of characters furnished by the adults differs only in the addition of the groups *Bezzia*, *Macropeza*, and *Ceratopogon*, but of these Mayer had no representatives of the second and third available for comparison. A study by the present writer of pinned and alcoholic material, as well as of figures published by Macfie, deMeillon, Root, Hoffman, et al., of the hypopygia, indicates that these structures permit a somewhat similar arrangement. However, I consider that *Atrichopogon* merits a distinct position since it may readily be distinguished from the others on characters furnished by the larvae and pupae, by the structure of the hypopygium of the male, as well as other structural features of the adult. Too little is known of the hypopygial characters of the *Macropeza* group to warrant expressing an opinion. Regarding this group Macfie (1940a) writes, "all the genera included in the *Macropeza* group might have been placed either in the *Palpomyia* or in the *Bezzia* group, but as this could have been done only by arbitrary means I have preferred to keep them apart." In agreement with Mayer I should prefer to include *Bezzia* and related forms with the *Palpomyia* group on the basis of the structure of the hypopygia.

It is generally admitted by recent writers that certain characters which have been used for defining genera such as the presence of a dividing vein between the two anterior radial cells, the abundance of macrotrichia on the wing, eye pubescence, the presence of spines on

#### EXPLANATION OF PLATE I

Wings. 1. *Forcipomyia cilipes* (Coq.). ♂. 2. *Lasiohelea* sp. ♀. 3. *Pterobosca* sp. ♀. 4. *Atrichopogon peregrinus* (Joh.). ♀. 5. *Dasyhelea mutabilis* (Coq.). ♂. 6. *Culicoides guttipennis* (Coq.). ♀. 7. *Ceratopogon culicoides* Hoffm. ♀. 8. *Alluaudomyia neothami* Thom. ♀. 9. *Brachypogon impar* Joh. ♀. 10. *Stilobezzia mallochii* Hoffm. ♂. 11. *Eukraiohelea elegantula* (Joh.). ♀. 12. *Stilobezzia uncinata* Joh. ♀. 13. *Schizhelea leucopesa* (Meigen). ♀. 14. *Monohalea* sp. ♀. 15. *Diaphanobezzia pellucida* Macfie. ♂. 16. *Serromyia femorata* (Meigen). ♀.

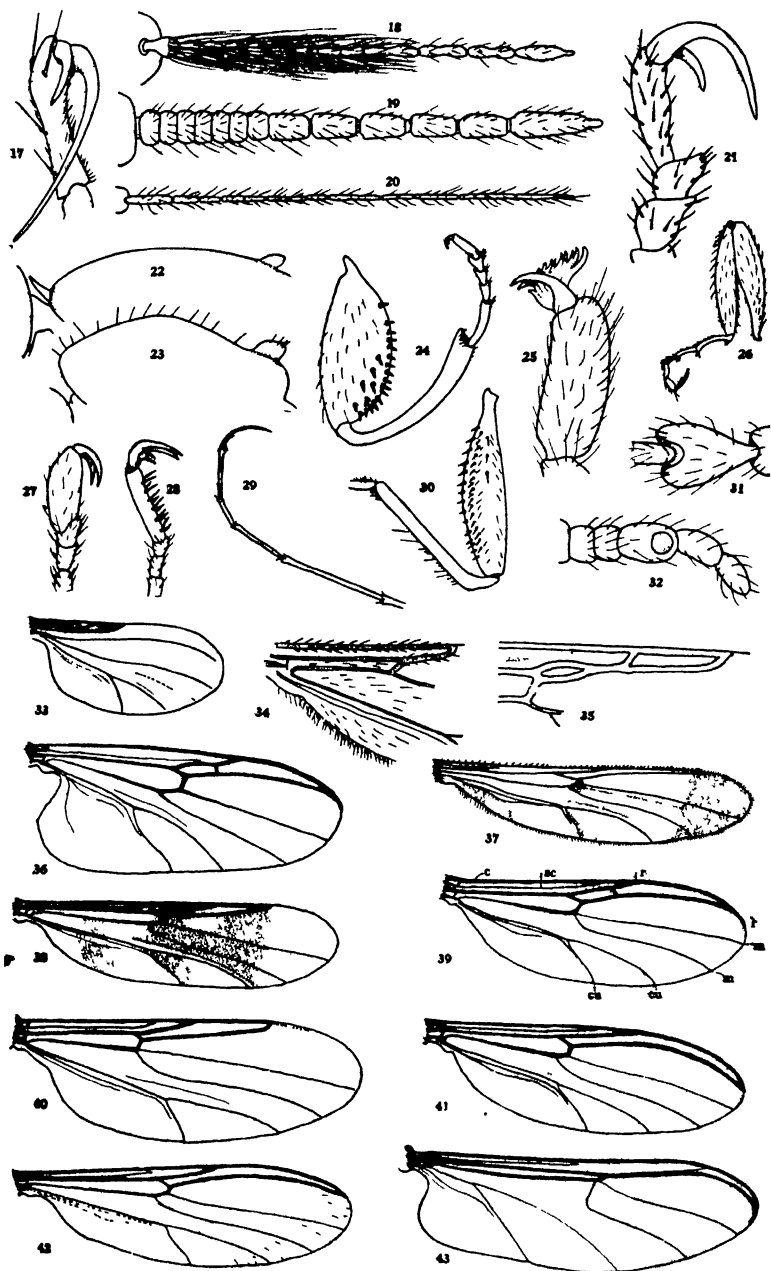


the femora and on the fifth tarsal segments, and the structure of the tarsal claws, are at most of subgeneric importance. Indeed, the last two items are significant only in the characterization of the female, and as such are undesirable for generic definition. That analysis must precede synthesis is self-evident and therefore the recognition of minor groups is necessary to draw attention to the presence of characters which might otherwise be overlooked, but the erection of subgenera would serve this purpose, leaving the genus for the higher category. The multiplication of generic names, often based on trivial characters of specific importance only, may lead to the erection of a genus for every difference, and thus we should approach the "Méthode mononymique" such as was proposed by Amyot (1845-7) a hundred years ago for the Hemiptera of France. Genera with a large number of species offer no special hardship to the systematist and certainly make for greater stability in nomenclature. Perhaps a system which would have recognized as genera the divisions approximating the groups mentioned above, with the subdivisions either named or unnamed, would have answered every purpose.

For the convenience of entomologists interested in the American Ceratopogonidae a revised key is given here in which the genera thus far recorded from North and South America are included. In forming this key I have drawn largely upon the works cited in the first paragraph of this article. I also wish to acknowledge my indebtedness to those in charge of the collections in the U. S. National Museum and the Illinois State Laboratory of Natural History for the privilege of examining the types of most of the North American species, and to Dr. F. H. Butt for the inking of a part of the figures on Plate II and most of those on Plate III.

#### EXPLANATION OF PLATE II

Antennae, legs, wings, etc. 17. *Schizothela leucopsea* (Meigen), fifth segment of hind tarsus, ♀. 18. *Dasythela oppressa* Thom., flagellum of antenna, ♂. 19. *Pterobosca* sp., flagellum of antenna, ♀. 20. *Ceratobezzia flavida* Joh., flagellum of antenna, ♀. 21. *Stilobezzia uncinata* Joh., segments 3-5, fore tarsus, ♀. 22. *Ceratobezzia flavida* Joh., contour of thorax, lateral aspect, ♀. 23. *Dicrobezzia smithi* (Coq.), contour of thorax, lateral aspect, ♀. 24. *Heteromyia fasciata* Say, fore leg, ♀. 25. *Atrichopogon fuscinervis* (Malloch), fifth segment of fore tarsus, ♀. 26. *Monothela* sp., hind leg, ♀. 27. *Clinothela bimaculata* (Loew), segments 2-5, fore tarsus, ♀. 28. *Lasiobezzia unica* Joh., segments 2-5, fore tarsus, ♀. 29. *Heteromyia fasciata* Say, var. *festiva* Loew, segments 2-5, hind tarsus, ♀. 30. *Serromyia femorata* (Meigen), hind femur and tibia, ♂. 31. *Stilobezzia mallochi* Hoffm., fourth tarsal segment. 32. *Forcipomyia eques* (Joh.), palpus, ♀. 33. *Leptoconops kerteszi* var. *americana* Carter, wing, ♀. 34. *Paradasythela brevipalpis* Macfie, base of wing, ♂. After Macfie. 35. *Isthmothela disjuncta* Macfie, base of wing, ♀. After Macfie. 36. *Jenkinsiella albaria* (Coq.), wing, ♀. 37. *Paraphoconus angustipennis* Endr., wing, ♀. After Enderlein. 38. *Heteromyia fasciata* Say, var. *pratii* Coq., wing, ♀. 39. *Neurothela* sp., wing, ♀. 40. *Probezia copiosa* Thom., wing, ♂. 41. *Dicrobezzia smithi* (Coq.), wing, ♀. 42. *Lasiobezzia unica* Joh., wing, ♀. 43. *Stenoxenus fulvus* Joh., wing, ♀.

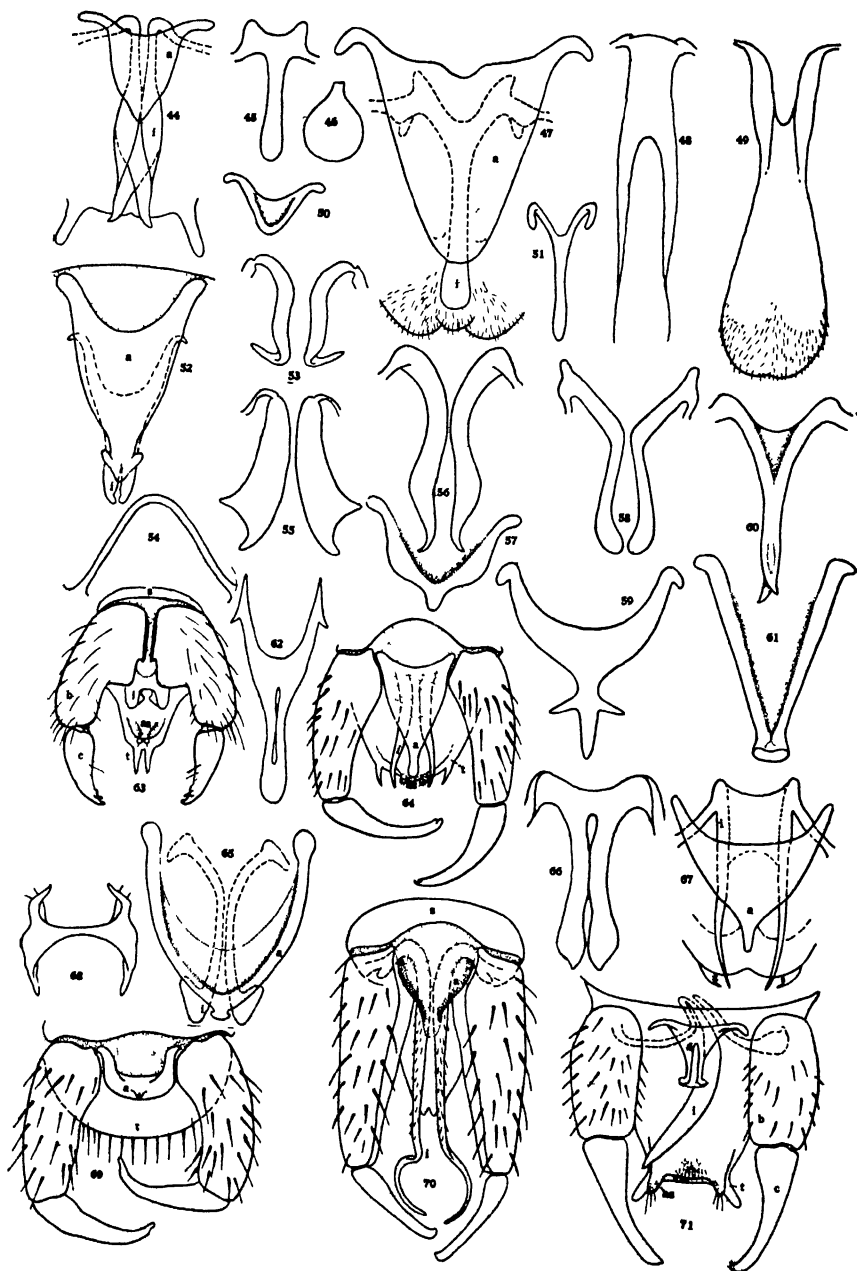


KEY TO NORTH AND SOUTH AMERICAN GENERA  
OF CERATOPOGONIDAE

1. Radio-medial crossvein absent (fig. 33). Antennae of the female with 12 to 14 segments (including the minute scape and globose pedicel). Dististyles (claspers) of the hypopygium apically bifid or trifid (fig. 63). Larva with neither prolegs nor anal bristles; head capsule not sclerotized; mouth parts reduced. Pupa with segments 3 to 7 similar, anal segment with tubercles; respiratory trumpets elongate, ending in a short ovate or barrel-shaped structure with about ten spiracles. (LEPTOCONOPS GROUP)..... 2
- Radio-medial crossvein present; media with two branches, lower branch in some cases interrupted at base (wholly wanting in *Brachypogon*). Antennae of female with 15 segments including the pedicel and the minute basal scape..... 8
2. Antennae of female with 14 segments..... (*Teresesthes*) **Leptoconops**
- Antennae of female with 13 segments..... **Holoconops**
3. Empodium well developed, nearly as long as the claws (fig. 25)..... 4
- Empodium small or vestigial..... 8
4. Microtrichia prominent, distinctly visible under a magnification of 100 diameters; macrotrichia suberect, rather sparse, lacking in the males of some species and in some cases in the females also. Costa extending to or beyond the apical third of the wing (fig. 4); second radial cell longer than the first; intercalary fork in the posterior radial cell; media with a short petiole. Eyes nearly or quite bare (*Atrichopogon*, s. s.) or finely pubescent all over (*Kempia*). Antennae of female with the last five segments cylindrical, the others globular or transverse. Hypopygium with inner processes (i. e., so-called harpes or parameres) apparently lacking or perhaps membranous; ninth sternite narrow, posterior margin emarginate; ninth tergite long, posterior margin rounded, usually without notch; aedeagus usually about as broad as long, more or less shield-shaped (fig. 69). Larva with anterior and posterior prolegs; all body segments with short spines; anal segment with a double row of hooks; body flattened, transversely oval in cross-section; lateral processes at least as long as the segment. Head capsule present; pharyngeal skeleton with about six combs, the angulus with bristles; mouth parts well developed. Pupa with the larval exuviae attached to the last three segments; respiratory trumpets short, knob-like; abdominal segments with branched or setaceous projections on the first five (ATRICHOPOGON GROUP),  
**Atrichopogon**

## EXPLANATION OF PLATE III

Terminalia (ventral aspect). Abbreviations: *a*, aedeagus; *b*, basistyle; *c*, clasper (dististyle); *i*, inner process; *s*, ninth sternite; *as*, anal segment; *t*, ninth tergite. 44. *Ceratopogon culicoidithorax* Hoffm., aedeagus and inner process. 45. *Probezzia copiosa* Thom., inner process. 46. *Pterobosca* sp., spermatheca. 47. *Palpomyia trivialis* (Loew), aedeagus and inner process. 48. *Forcipomyia chiliensis* Macfie, inner process. After Macfie. 49. *Sphaeromyia longipennis* (Loew), inner process. 50. *Probezzia glabra* (Coq.), aedeagus. 51. *Bessia varicolor* (Coq.), inner process. 52. *Dicrobezzia smithi* (Coq.), aedeagus and inner process. 53. *Palpomyia*, near *tibialis* (Meigen), inner process. 54. *Lasiohelea nigeriae* Macfie, inner process. After Macfie. 55. *Stilobezzia* sp., inner process. 56. *Stilobezzia mallocki* Hoffm., inner process. 57. *Stilobezzia mallocki* Hoffm., aedeagus. 58. *Serromyia femorata* (Meigen), inner process. 59. *Serromyia femorata* Meigen, aedeagus. 60. *Heteromyia fasciata* Say, inner process. 61. *Heteromyia fasciata* Say, aedeagus. 62. *Jenkinshelea corea* deM., inner process. After deMeillon. 63. *Leptoconops kertessi*, var. *americana* Carter, hypopygium. 64. *Culicoides guttipennis* (Coq.), hypopygium. 65. *Johannsenomyia caudelli* (Coq.), inner process. 66. *Palpomyia africans* Macfie, inner process. After Macfie. 67. *Forcipomyia specularis* (Coq.), hypopygium. 68. *Forcipomyia (Apelma) brevis* Joh., inner process. 69. *Atrichopogon fuscinervis* (Malloch), hypopygium. 70. *Alluaudomyia needhami* Thom., hypopygium. 71. *Dasyhelea oppressa* Thom., hypopygium.



Microtrichia minute; macrotrichia more or less depressed, elongate, sometimes scale-like, abundant, covering the greater part of the wing (figs. 1-3). Costa ending at or near the middle of the wing; first radial cell narrow and almost obliterated, second small but usually distinct, in a few cases more elongate (figs. 2, 3). Eyes bare, except in a few species of *Lasiohelea*. Hypopygium of the male with the inner processes slender, tapering, often attenuated caudad, these may be connected anteriorly at the base by a transverse rod or plate (figs. 48, 67). In the subgenus *Apelma* the structure is more compact (fig. 68), the caudad projecting processes very short. In a few species these processes appear to be entirely lacking, only the transverse bar remaining visible, as in some species of *Lasiohelea* (fig. 54). Larvae terrestrial, with both anterior and posterior prolegs; body segments circular in cross-section and with short spines. Head structure resembling that of *Atrichopogon*. Pupa similar to that of *Atrichopogon*, but with spines or stump-like projections on all but the last segment (FORCIPOMYIA GROUP)..... 5

5. Antennae of female with the last six segments elongate (fig. 19). Empodium large and broad, adapted for clinging to the wings of dragonflies. Basitarsus of the hind legs much longer than the second tarsal segment. Second radial cell ends at about the middle of the wing (fig. 3). . . . . *Pterobosca*

Antennae of the female with the last five segments elongate, or in some cases forming an almost continuous series..... 6

6. First radial cell small and very narrow, in some cases obliterated; second radial cell elongate and narrow, usually ending well beyond the middle of the wing (fig. 2); wing fringe hair-like; microtrichia small as in *Forcipomyia*; macrotrichia covering the wing more or less densely, in some cases with definite bare areas along the course of the veins as in *Dasyhelea*. Eyes usually bare. Antennae of female with the basal flagellar segments rounded or transverse, the last five much elongated though in some cases forming an almost continuous series. Hind basitarsus distinctly longer than the second tarsal segment. The hypopygium of the male with the internal process lacking the posteriorly projecting rods or plates, the strongly sclerotized dorsal root-like processes arising from the bases of the side pieces (basistyles) are long and join anteriorly across the median line forming a wide arch (fig. 54). The adults are vicious biters..... *Lasiohelea*

Second radial cell short, sometimes obliterated, not much longer than the first which may also be obliterated; fringe hairs of the wing in many cases lanceolate..... 7

7. Hind basitarsus shorter, equal or but slightly longer than the second tarsal segment. Basal segments 3 to 10 of the antennae of the female of many species longer than broad, often vasiform or flask-shaped. Hypopygium in most cases of the form as figured (figs. 48, 67). Wing as in fig. 1. In the subgenus *Phasmidohelea* (parasitic on Phasmids) the mouth-parts are peculiarly modified..... *Forcipomyia*

Hind basitarsus over a third and in many cases two or more times as long as the second tarsal segment. Basal segments 3 to 10 of the antenna of the female in many species short, the first few often broader than long as in *Pterobosca* (fig. 19) and in *Atrichopogon*. In the subgenus *Apelma* the hypopygium of the male is characteristic, the inner processes being more or less H-shaped (fig. 68), and the empodium is lacking. (*Forcipomyia* Meigen in part)..... *Euforcipomyia*

8. First radial cell nearly or quite obliterated by the fusion of the basal section of the radial branches, second cell small, square-ended, sometimes obliterated, the radial veins truncated at the middle of the wing (fig. 5), medial fork sessile or with very short petiole; wing surface with macrotrichia. Eyes very short pubescent. (The males of *Apelma* have a short costa and lack an empodium but the eyes are quite bare.) Usually no distinct humeral pits. Claws small and equal, empodium vestigial. Antenna of the male with the last four segments elongate (fig. 18). Hypopygium with the inner processes in most cases asymmetrical (fig. 71); ninth sternite in some cases emarginate, more often with a central posterior extension; ninth tergite rather long, tapering, with a finger-like

- process on each latero-posterior angle; aedeagus broad; dististyle of forceps either simple, or with a basal branch. Larva aquatic, with creeping habit; body curved; anterior prolegs wanting; last segment with retractile proleg bearing ten to twelve hooks; head short and thick, well sclerotized, mouth-parts directed ventrally; pharyngeal skeleton with about six combs, the angulus with well developed teeth. Pupa free from the larval exuviae, respiratory trumpet elongated; abdominal segments two to seven similarly bristled, anal segment in addition to the two apical processes with at least one pair of protuberances (DASYHELEA GROUP)..... 9
- Second branch of the radius in most cases ending beyond the middle of the wing, or differing in other particulars..... 10
9. Antennal segments reticulately sculptured, last four segments in the male more or less elongate, segments 12 to 14 binodose (fig. 18). Hind basitarsus at least twice as long as the following segment; claws short and equal..... *Dasyhelea*
- Antennal segments not sculptured; segments 12 to 14 of the male not binodose. Anterior radial cells of the wing obliterated (fig. 34). In *P. brevipalpis* I. & M., the genotype, there are small humeral pits; the petiole of the media is rather long, fringe present on alula; the tarsal ratio less than two; and the palpi modified, the elongate second segment without sensory pit but having four sensory hairs on its anterior third, fourth segment with three bristles at its rather squared extremity. South American..... *Paradasyhelea*
10. Media forks distad of the radio-median crossvein, *i. e.*, petiolate; or its second branch detached at base, in rare cases lacking..... 11
- Media forks at or proximad of the crossvein..... 28
11. Claws of both sexes all simple, small, and equal. Usually with the two anterior radial cells of the wing more or less equal; microtrichia dense, macrotrichia usually abundant, in some cases nearly or quite lacking; wing often spotted (fig. 6), costa ending beyond the middle of wing. Mesonotum with an elongate slit-like depression or pit on each side situated postero-medially from the humeri. Eyes usually bare. Antenna of female with segments 3 to 10 rounded or oval, 11 to 15 more or less cylindrical and longer. Basitarsus of hind legs at least twice as long as the segment following it; empodium very short. Hypopygium (fig. 64) with the caudad projecting inner processes slender and tapering, usually with pointed, twisted or hooked or curved or pectinate extremity; ninth sternite emarginate; ninth tergite usually with a sharply pointed process at each postero-lateral angle; the anal segment membranous with a pair of hairy tubercles which may project beyond the posterior margin of the ninth tergite; aedeagus with V- or Y-shaped, sclerotized margins. Larva an aquatic, free swimming, slender, eel-like form without prolegs. Head wide, oval, well sclerotized; mouth-parts reduced; pharyngeal skeleton with about four combs, the angulus of distinctly separate parts; cauda with bristles. Pupa free from the larval exuviae; respiratory trumpet elongate, tubular, with a constriction at base; operculum with spines. The adults are vicious biters (CULICOIDES GROUP)..... *Culicoides*
- Claws of the female usually rather large, either equal or unequal. Wings in most cases with two anterior radial cells, the second often larger than the first; macrotrichia usually absent or confined to the apex of the wing (abundant in *Alluaudomyia*); humeral pits more or less developed..... 12
12. Eyes more or less pubescent. Antennae of the male with the last three segments elongate; of the female with segments 3 to 10 rounded, 11 to 15 not very long. Wing (fig. 7) broad, milky white, microtrichia apparently absent, not visible under a magnification of 700 diameters; macrotrichia absent or confined to a few around the apical margin; two anterior radial cells which are small and equal, or one or both may be obliterated; medial fork with a distinct petiole, the second branch entire or more or less interrupted at the base, entirely wanting in *Brachypogon* (fig. 9); costa extending nearly to two-thirds the wing length (figs. 7, 8) except in *Brachypogon*; alula and squama bare. Hypopygium with the caudad



- projecting processes, paired, robust, either tapering (figs. 44, 70) or ending bluntly. The larva and pupa of *Alluaudomyia* are briefly described below (CERATOPOGON GROUP).....18
- Eyes usually bare. Microtrichia present (except in *Diaphanobezzia*) distinct under a magnification of 300 diameters or less; second radial cell, when present, in most cases distinctly longer than the first; posterior branch of the radius usually ending far beyond the middle of the wing (figs. 10-16, 35). Inner processes of the hypopygium paired, robust, blunt or pointed at the extremity but not attenuated (figs. 55-59), fused on the middle line in some species of *Monohalea*. Larva and pupa briefly characterized below under *Stilobezzia* (STILOBEZZIA GROUP).....16
13. Claws of the hind legs of female unequal. Wings minutely punctate but microtrichia absent; macrotrichia rather abundant; first radial cell nearly or quite obliterated by the coalescence of the basal section of the radial veins, second radial cell small but distinct; wing spotted (fig. 8). Larva aquatic, slender, eel-like, without prolegs; posteriorly with long setae; dorsal surface of body mottled with red pigment. Pupa free from larval exuviae; respiratory trumpet funnel-shaped, covered with scales.....*Alluaudomyia*
- Claws of hind legs of female equal in most cases. Wings unmarked; macrotrichia scanty or absent.....14
14. Second branch of media lacking; costa not extending distally as far as the level of the second branch of the cubitus; anterior radial cells either small and subequal (*Trishelea*) or entirely obliterated (*Brachypogon* s. s.) (fig. 9); no macrotrichia.....*Brachypogon*
- Second branch of media present, at least apically.....15
15. Second branch of the media entire (fig. 7) or only narrowly interrupted at the base; costa extending distally nearly two-thirds the wing length, i. e., nearly as far as the level of the end of the first branch of the cubitus; anterior radial cells subequal, longer than broad; macrotrichia sometimes present near wing tip; alula and squama bare. Eyes more or less pubescent. Antennae of the female with segments 3 to 10 rounded, 11 to 15 not very elongated; antenna of male with last three segments elongated. (*Helea* Meigen).....*Ceratopogon*
- Second branch of the media widely interrupted at the base; anterior radial cells little if any longer than broad (lacking in the European *I. minima* K.); macrotrichia nearly or wholly lacking. Type *I. lactipennis* Winn. nec Zetterstedt (= *I. sociabilis* Gtg.). Compare *C. stigmatis* Coq. with unequal claws on all feet.....*Ischohelea*
16. Microtrichia and macrotrichia lacking; a single rather short anterior radial cell (fig. 15); alula without hair fringe. Femora armed at apex with spines; tibiae sparsely spinose; fourth tarsal segment short but not cordate; fifth unarmed; claws small, equal in male.....*Diaphanobezzia*
- Microtrichia present.....17
17. The two anterior radial cells separated for some distance by the fusion of the veins between them (fig. 35); macrotrichia almost or quite lacking; costa ends beyond the middle of the wing; media petiolate; alula without hair fringe. Femora unarmed and not swollen; hind tibiae and basitarsi of fore and middle legs with long scattered spines; fourth tarsal segment cordate or bell-shaped; claws of female barbed, two short, equal claws on fore and middle legs, a single long claw on hind legs. Genotype *I. disjuncta* I. & M., from South America.....*Isthmohelea*
- When two anterior radial cells are present they are separated by the short perpendicular section of the second radial vein (figs. 13, 14).....18
18. Claws of hind legs of female very unequal (fig. 17), or a single long claw with or without a smaller basal barb.....19
- Claws of female all equal.....25
19. Fourth segment of tarsus bilobed (fig. 31); claws of female unequal on all legs, or a single long claw with or without basal barb.....20
- Fourth tarsal segment cylindrical to bell-shaped but not bilobed; claws on four anterior legs of female all equal.....22
20. Femora not armed with spines; fifth tarsal segment not enlarged; claws of female large and very unequal on all legs. Wings with macrotrichia

- toward the tip (*Stilobessia* s. s.) or without (*Neostilobessia*). Two anterior radial cells (fig. 10) or more rarely with the first much reduced or even obliterated; fork of media with long petiole; a row of hairs on the alula. In one species there is but one anterior radial cell and the costa is produced beyond it (fig. 12). Larva without prolegs; body curved; slow moving, aquatic forms; head broad, mouth-parts reduced, directed anteriorly; pharyngeal skeleton with several combs, the principal comb of the angulus undivided. Pupa as with *Culicoides*. . . . . **Stilobessia**
- Some or all the femora armed with spines or stout bristles. . . . . 21
21. First radial cell obliterated (fig. 11). Only the fore femora armed; claws of female unequal on all legs. . . . . **Eukraiohelea**
- Two anterior radial cells. All femora armed with spines or stout bristles. New South Wales and British Guiana. . . . . **Acanthohelea**
22. Hind femora much swollen and armed with numerous spines (fig. 30), the corresponding tibiae slender, curved at base. Wing with two sub-equal anterior radial cells (fig. 16); in some species with a few macrotrichia around the tip of the wing; medial fork short petiolate or sometimes almost sessile. Fourth tarsal segment short, bell-shaped to cordate; claws about equal on fore and middle legs, very unequal on hind legs of female in most cases. . . . . **Serromyia**
- Hind femora without spines and either not swollen or if somewhat swollen then hind tibiae also swollen (fig. 26). . . . . 23
23. The two anterior radial cells separated for some distance by the fusion of the veins between them (fig. 35). See couplet 17. . . . . **Isthmohelea**
- Anterior radial cells when two are present separated by the short perpendicular section of the second radial vein (fig. 14). . . . . 24
24. Second branch of media complete (fig. 14); few or no macrotrichia; two distinct anterior radial cells, the second considerably longer than the first; medial fork short petiolate. Fore and middle legs unmodified, claws rather small and equal in both sexes; femora and tibiae of hind legs distinctly thickened (fig. 26), but femora without spines; first tarsal segment with strong spine at tip; fourth cylindrical. . . . . **Monehelea**
- Second branch of media broadly interrupted at base (fig. 13). No strong spines on the basal segments of tarsi; claws on hind legs of female very unequal (fig. 17). . . . . **Schizöhelea**
25. Two anterior radial cells. . . . . 26
- One anterior radial cell. . . . . 27
26. Posterior end of abdomen of female modified, the tenth segment being long and cylindrical and bent forward. Wings without macrotrichia; costa extends two-thirds or more the length of the wing; anal angle large, more or less rectangular; second anterior radial cell longer than the first. Femora and tibiae unarmed and not swollen; fifth tarsal segment unarmed and not swollen. A South American genus, **Macruröhelea**
- Abdomen of female normal. Wing pictured. All femora armed with spines or stout bristles. South American. . . . . **Acanthohelea guianae** Macfie
27. Fore femora armed with spines. Venation about as in *Bessia* except that the media forks distad of the radio-median crossvein. Fourth tarsal segments cordate; claws simple and equal. . . . . **Pseudobessia**
- Femora unarmed; claws equal and of moderate size; fifth tarsal segment without ventral spines. Venation as in *Pseudobessia* except that the median fork has a longer petiole. . . . . **Parabessia**
28. Thorax narrowed in front, more or less conical. Wing long and narrow (MACROPEZA GROUP). Wing with microtrichia; radio-medial crossvein distinct but short; costa not produced and ending well before the wing tip; a single long anterior radial cell (fig. 37); the posterior branch of the radius closely approaching the costa; median fork sessile. Legs long and slender, last three tarsal segments relatively short; fourth cordate; claws of female all equal, each with a basal barb. South America. . . . . **Paraphoconus**
- Thorax not narrowed in front. Wings with microtrichia; either one (fig. 40) or two anterior radial cells present (fig. 38). Terminal segment of forceps simple; inner processes fuse into a single member (figs. 45,

- 47, 49, 51, 52, 60, 62) or less commonly, as in some species of *Palpomyia*, distinctly separated (figs. 53, 65) although they may be connected at base (fig. 66). Larvae actively swimming eel-like forms, without prolegs. Head narrow, well sclerotized; mouth parts reduced; pharyngeal skeleton with three combs; principal comb of angulus divided. Abdominal segments 3 to 7 of pupa similarly bristled; anal segment with bristles on bristle tubercle. Pupa free from larval exuviae; respiratory trumpet clavate, with numerous spiracles (**PALPOMYIA-BEZZIA GROUP**).....29
29. Anal lobe of wing large, produced; wing broad, especially at base (figs. 36, 43); costa usually more or less produced beyond the end of the posterior branch of the radius; either one or two anterior radial cells.....30
- Anal lobe obtuse angled, not produced; wing usually of moderate width.....31
30. Posterior branch of media elbowed in female; a single very narrow anterior radial cell (fig. 43); costa elongate, extending to tip of wing. Femora unarmed; fourth tarsal segment not bilobed, subcylindrical; fifth segment unarmed; claws small and equal.....**Stenoxenus**
- Posterior branch of media not elbowed in the female; one or two anterior radial cells (fig. 36); microtrichia present; medial fork broadly sessile. Anterior margin of thorax somewhat jutting over the head but not pointed. Femora unarmed, fourth tarsal segment cordate or bell-shaped, broader than long; fifth segment with strong, blunt spines (batonnets) below.....**Jenkinshelea**
31. With two anterior radial cells (fig. 39).....32
- With but one anterior radial cell (fig. 40).....40
32. Costa produced beyond the apex of the posterior branch of the radius (fig. 39); medial fork just sessile. Fourth tarsal segment cordate; fifth segment of fore legs swollen in both sexes as in *Clinohoelea*; claws in the female all equal and barbed.....**Neurohoelea**
- Costa not produced beyond tip of posterior branch of radius.....33
33. Femora of fore legs armed and greatly swollen, the corresponding tibiae arched (fig. 24); hind legs of female very long, with a single long, basally barbed claw (fig. 29); claws of male small and equal; first and second pairs of the female equal and barbed. Apical third of hind femur of both sexes distinctly enlarged; fourth tarsal segments on all feet of the male and the first two pairs of the female, cordate. Antenna of male plumose. Wings of the North American species fasciate (fig. 38).....**Heteromyia**
- Fore femora not swollen, or if moderately so, fore tibia not arched.....34
34. Claws of middle and hind legs of the female unequal and simple, or a single claw with a basal barb; fifth segment of fore tarsi inflated (fig. 27) and unarmed on all legs; fourth tarsal segment on four posterior legs deeply bilobed, each lobe terminating in a strong spine. Venation as in *Heteromyia*.....**Clinohoelea**
- Claws of hind legs of female equal, or if unequal then each with a basal barb.....35
35. Femora and tibiae all armed with spines, some rather long, scattered irregularly; tarsi with short fourth segment which is not clearly cordate or bilobed; fifth segment unarmed; claws barbed, equal or unequal. Second radial cell much longer than the first. South America.....**Echinohoelea**
- Femora either unarmed, or if armed the spines are short and stout.....36
36. Claws unequal in the female, at least on middle and hind feet, and all barbed; fourth tarsal segment not cordate; fifth armed below with straight, somewhat blunt, black spines (batonnets); femora with or without spines on the under side. Venation as in *Heteromyia*. Minute notal spine present as in *Palpomyia* in the North American species *D. argentata* (Loew) and *D. annulicornis* (Malloch).....**Dicrohoelea**
- Claws of female all equal.....37
37. Claws of female without basal barb and as long or nearly as long as the last tarsal segment; fourth segment but little longer than broad, cordate or nearly so; fifth segment of female armed with stout blunt spines (batonnets) on the under side. Oriental and South American species. The North American species assigned here by Kieffer belong elsewhere.....**Homohoelea**
- Claws of female all equal and barbed, or, if not barbed, stout blunt spines (batonnets) are lacking in the female on the under side of the fifth tarsal

- segment, although stout, sharp, more or less curved bristles may be present. . . . . 38
38. Femora without strong spines below; fifth tarsal segment in the female armed with stout, blunt, black spines below (batonnets). Venation as in *Heteromyia*. Scutum without short minute, spine or tubercle anteriorly; abdomen of female without eversible glands. . . . **Johannsenomyia**  
Femora armed with short stout black spines below. . . . . 39
39. Tarsi with fourth segment short, subcylindrical. Stout, robust species. Eyes nearly contiguous. Scutum in most cases without minute, anteriorly directed spine. Abdomen without eversible glands in the female. Fifth tarsal segment in the female with stout, black, blunt spines (batonnets) on the underside. Male antennae either with or without plume, **Sphaeromias**
- Fourth tarsal segment cordate; fifth segment without stout, blunt spines below, but stout, sharp, somewhat curved bristles may be present. Scutum with a minute, pointed spine or tubercle anteriorly, sometimes apparently lacking. Abdomen of female with pairs of eversible glands in many species. Forceps of hypopygium with simple terminal segment; the inner caudad projecting processes either separate (fig. 53), or partly (fig. 66), or completely fused (fig. 47). Fore femora either slender or moderately swollen, with one or more short, stout spines on the lower side; middle and hind pairs slender, with or without stout spines below. Tarsal claws of moderate size, equal, with or without basal barbs. Wings rather narrow, with fine microtrichia but without macrotrichia. Venation as in *Heteromyia*, the costa extending to two-thirds the wing length or more, not produced beyond the end of the posterior branch of the radius; second anterior radial cell much longer than the first; median fork broadly sessile; anal lobe not well marked, alula absent, the short piece of wing margin between the anal lobe and the squama without fringe. . . . . **Palpomyia**
40. Wing without macrotrichia. . . . . 41  
Wing with macrotrichia (fig. 42); venation as in *Dicrobezzia* (fig. 41) or in *Probezzia* (fig. 40). Fourth tarsal segment cordate; empodium absent. In the genotype, *L. pilipennis*, from north Sweden, the fore femora are armed, the claws are simple, the fifth tarsal segment unarmed in the female, and the posterior branch of the radius ends at about two-thirds the wing length as in *Probezzia*. In the New York species, *L. unica*, the femora are unarmed, the fifth tarsal segment with stout, blunt spines below (fig. 28), the claws equal and barbed, the posterior branch of the radius elongate, disc of the scutum with short, erect bristles as in *Dicrobezzia* (fig. 23). The presence of the macrotrichia on the apical half of the wing being probably of less significance than the other characters cited the two species are not closely related. . . . . **Lasiobezzia**
41. Fourth segment of all tarsi bilobed or cordate. . . . . 42  
Fourth segment of tarsi subcylindrical; claws of female equal and with basal barb. . . . . 45
42. Mesonotum but slightly convex, with a prominent, anteriorly, and somewhat upward directed tubercle on the anterior margin (fig. 22). Abdomen elongate. Antenna of the female with short, stout, sparsely distributed hairs (fig. 20). Tarsal segments three to five very short, the fourth segment bilobed or cordate. In the genotype *C. fallax* K. from Paraguay the fifth tarsal segment of the fore legs is inflated, which is not the case in *C. flavida* Joh. from British Guiana. . . . . **Ceratobezzia**  
Mesonotum without large, stout spine on the anterior margin. . . . . 43
43. Costa of the wing and second radial cell of the female very long, reaching nearly to the wing tip (fig. 41). Dorsum of the thorax with short, sparsely distributed, erect bristles in addition to the decumbent hairs (fig. 23). Femora unarmed; fifth tarsal segment of the female with strong, blunt, black spines (batonnets) below. . . . . **Dicrobezzia**  
Costa not prolonged. Fifth tarsal segment of the female unarmed. . . . . 44
44. At least the fore femora spinose beneath; fifth tarsal segment of fore feet not inflated; claws of female equal on all legs. Venation as in *Probezzia* (fig. 40), the fork of the media narrowly sessile, the contact often punctiform. Scutum without trace of minute anterior tubercle. . . . . **Bezzia**

- Femoral spines lacking, in other respects like *Bezzia* from which it is not regarded by some writers as sufficiently distinct to warrant generic rank. Wing venation as figured (fig. 40).....**Probezzia**
45. Fore femora armed with stout spines beneath; fifth tarsal segment unarmed. Africa and South America.....**Homobezzia**
- Femora with neither spines nor spinose bristles; fifth tarsal segment armed. East Indies and South America.....**Parrotia**

## LIST OF NORTH AMERICAN SPECIES

The first locality reference given indicates that of the type. In the case of widespread species the range only is given. A figure and a date following an author's name refer to page and date of the paper in which the description is published. Synonyms are indented and printed in smaller type. Williston's St. Vincent Island species, though more properly South American, are included in this list. Some half dozen of North American species of doubtful position are marked with a (?). A few genera of early date which are not sufficiently characterized to place with certainty, have also been indicated in the following list with a (?). These are *Didymophleps* (*Atrichopogon*?), *Tetrahelea* (*Dasyhelea*?), *Prosapelma* (*Culicoides*?), *Tetrabezzia* (*Bezzia* or *Macropeza* group).

### LEPTOCONOPS GROUP

#### **Leptoconops** Skuse (1889)

Synonyms: *Tersesithes* Towns., 1893; *Centrotypus* Grassi, 1901; *Mycterotypus* Noé, 1905; *Mycteromyia* Lutz, 1912, nec Phil.; *Schizoconops* K., 1918; *Protersesithes* K., 1921a.

**torrens** Towns. 369, 1893. New Mexico, Colorado, California.

*carteri* Hoffm. 133, 1926b.

A few South American species.

#### **Holoconops** Kieffer (1918)

**bequaerti** K. 405, 1925a. Central America.

*hondurensis* Him. 135, 1926b.

**kerteszi** var. **americana** Carter. 22, 1921. Utah, Southwestern United States.

Two other genera not yet reported from the Americas are *Microconops* K. (1921a) and *Styloconops* K. (1921a). The former, recorded from North Africa, differs from *Leptoconops* in having but twelve antennal segments in the female; the latter, from Africa and New Guinea, in having very short terminal lamellae in the female and with numerous spines or hairs on the frons.

### ATRICHPOGON GROUP

#### **Atrichopogon** Kieffer (1906a)

Synonyms: ?*Didymophleps* Weyenb., 1883; *Kempia* K., 1913a; *Ceratopogon* of Mall., 1915a; *Gymnohelea* K., 1921a; *Lophomyidium* Cordero, 1929; *Psilokempia* Endr., 1936.

**arcticus** Coq. 396, 1900. Alaska.

**exilis** Coq. See *levis*.

- fusinervis** Mall. 308, 1915*a*. Illinois.  
**fuscus** Coq. 605, 1901. Northeastern United States.  
**gilvus** Coq. 62, 1905. Florida.  
**levis** Coq. 604, 1901. Eastern United States.  
*exilis* Coq. 88, 1902. District of Columbia.  
**litratus** Will. (?). 281, 1896. St. Vincent Island.  
**peregrinus** Joh. 266, 1908*a*. Eastern United States.  
**sequax** Will. (?). 282, 1896. St. Vincent Island.  
**thersites** Will. 180, 1896. St. Vincent Island.  
**websteri** Coq. 603, 1901. Louisiana, New York.  
Numerous South American species.

*Dolichohelea* Edwards (1929) with *D. polita* Edw. as type, is a Philippine genus, allied to *Atrichopogon*, differs in having a small anterior tubercle on the mesonotum, with antennal segments 4 to 10 from one to five times as long as broad, and with an elongate radial cell resembling that of *Palpomyia*.

#### FORCIPOMYIA GROUP

##### **Lasiohelea** Kieffer (1921*a*)

Synonym: *Centrorhynchus* Lutz (1913).

- L.** sp. (undescribed). Georgia.  
A few South American species.

##### **Pterobosca** Macfie (1932*b*)

- incubans** Macfie. 486, 1937*a*. Honduras.  
One South American species.

##### **Forcipomyia** Megerle in Meigen (1818)

Synonyms: *Labidomyia* Stephens, 1829; *Tetrephora* Phil., 1865; *Prohelea* K., 1911*b*; *Microhelea* K., 1917*a*; *Phasmidohelea* Mayer, 1937*b*.

##### Subgenus **Forcipomyia** Meigen

- aurea** Mall. 318, 1915*a*. Illinois.  
**brumalis** Long. 3, 1902. Texas.  
**cilipes** Coq. 397, 1900. Alaska, eastern United States.  
**cinctipes** Coq. 64, 1905. Florida.  
**concolor** Mall. See *pergandei*.  
**coquilletti** K. 297, 1917*a*. New York.  
**crudelis** Knab. 66, 1914. Mexico.  
**crudelis** Mayer. 233, 1937. Costa Rica. (*Phasmidohelea*).  
**elegantula** Mall. 311, 1915*b*. Illinois.  
**eriphora** Will. 279, 1896. St. Vincent Island.  
**erucicida** Knab. See *flava* Will.  
**fimbriata** Coq. 601, 1901. District of Columbia.  
**flava** Will. 280, 1896. St. Vincent Island.  
*flavida* Will. M. S.  
*erucicida* Knab. 16, 1914. Florida.  
**genualis** Loew. 128, 1865. Cuba.  
**obscura** Walker. 26, 1848. Canada.

**parva** Walker (?). 26, 1848. Canada.  
**pergandei** Coq. 502, 1901. Eastern United States.  
**pergandei** var. **concolor** Mall. 319, 1915*a*. Illinois.  
**pilosa** Coq. 87, 1902*a*. Eastern United States.  
**pluvialis** Mall. 5, 1923. Maryland.  
**propinqua** Will. 279, 1896. St. Vincent Island.  
**simulata** Walley. 165, 1932. Ontario.  
**specularis** Coq. 601, 1901. Eastern United States.  
**squamipes** Coq. 88*a*, 1902. New Mexico, Eastern United States.  
**stenammatis** Long. 10, 1902. Larva.  
**texana** Long. 10, 1902. Texas.  
**tropicus** K. 297, 1917*a*. Costa Rica.  
**wheeleri** Long. 12, 1902. Larva. Texas.  
 Numerous South American species.

Subgenus **Euforcipomyia** Malloch (1915*b*)

(Including **Apelma** Kieffer (1919*a*) )

**calcarata** Coq. 64, 1905. Mexico.  
**eques** Joh. 266, 1908*a*. New York.  
**fusicornis** Coq. 63, 1905. Florida, Maryland.  
**hirtipennis** Mall. 313, 1915*b*. Illinois.  
**johannseni** Thom. 286, 1935. New York.  
**longitarsis** Mall. 314, 1915*b*. Illinois.  
**monilicornis** Coq. 63, 1905. British Columbia.

Several South American species.

To the *Forcipomyia* group the genus *Thyridomyia* Saunders (1925), recorded from Europe and Africa, may be added, as well as *Lepidohelea* K. (1917*a*) from Seychelles Islands. The former is characterized by a peculiar hypopygium, the inner processes being very short, and the ninth sternite deeply emarginate; the latter in having scales in addition to hairs and bristles.

DASYHELEA GROUP

**Dasyhelea** Kieffer (1911*c*)

Synonyms: *Prokemipia* K., 1913*a*; *Pseudoculicoides* Mall., 1915*a*; ?*Tetrahelea* K., 1925*a*; *Cryptoscena* Endr., 1936; *Dicryptoscena* Endr., 1936.

**ancora** Coq. 87*a*, 1902. Florida.  
**cincta** Coq. 605, 1901. Florida, Michigan.  
**grisea** Coq. 602, 1901. Florida, eastern United States.  
**johannseni** Mall. 311, 1915*a*. California.  
**major** Mall. 311, 1915*a*. Illinois, New York.  
**mutabilis** Coq. 602, 1901. Eastern United States.  
**oppressa** Thom. 285, 1935. New York.  
**pygmaea** Will. (?). 278, 1896. St. Vincent Island.  
**scutellata** Mg. 262, 1830. Greenland.  
**subcaerulea** Thom. 284, 1935. New York.  
**traveræ** Thom. 285, 1925. New York.  
**tenebrosa** Coq. 64, 1905. California.

Numerous South American species.

## CULICOIDES GROUP

**Culicoides** Latreille (1809)

Synonyms: *Oecacta* Poey, 1851; *Psychophaena* Phil., 1865; *Haematomyidium* Goeldi, 1905; *Cotocripus* Brèthes, 1912; *Haemophoructus* Macfie, 1925; *Synhelea* K., 1925a; *Prosapelmia* K., 1925a.

**albomaculatus** R. & H. 164, 1937. Mexico.

**arboricola** R. & H. 166, 1937. Maryland, Mississippi.

**baueri** Hfm. 297, 1925. Maryland, Mexico.

**biguttatus** Coq. 604, 1901. District of Columbia, northeastern United States.

**canithorax** Hfm. 284, 1925. Georgia, southeastern United States.

**chiopterus** Meig. 263, 1830. Eastern United States.

**cockerelli** Coq. 603, 1901. Colorado.

**cockerelli** var. **tristriatulus** Hfm. 294, 1925. California.

**copiosus** R. & H. 171, 1937. Mexico.

**crepuscularis** Mall. 303, 1915a. Illinois, United States.

**dampfi** R. & H. 169, 1937. Mexico.

**decor** Will. (?). 281, 1896. St. Vincent Island.

**diabolicus** Hfm. 294, 1925. Panama.

**dovei** Hall. 88, 1932. Georgia.

**filariferus** Hfm. 173, 1939. Puerto Rico.

**furens** Poey. 236, 1851. Cuba, West Indies.

*maculithorax* Will. 277, 1896. St. Vincent Island.

**gigas** R. & H. 172, 1937. Canada.

**guttipennis** Coq. 603, 1901. Ohio, United States.

**haematopotus** Mall. 302, 1915a. Illinois, northern United States.

**hieroglyphicus** Mall. 297, 1915a. Arizona, United States.

**hirtulus** Coq. 396, 1900. Alaska.

**hollensis** M. & B. (?). 13, 1903. Massachusetts.

**loughnani** Edw. 165, 1922. West Indies.

**loughnani** var. **jamaicensis** Hfm. 283, 1925. West Indies.

**luteovenus** R. & H. 156, 1937. Mexico.

**maculithorax** Will. See *furens*.

**melleus** Coq. 604, 1901. Florida, southeastern United States.

**minutissimus** Zett. 4860, 1855. Greenland.

*pumile* Winn. 46, 1852.

**mississippiensis** Hfm. 158, 1926a. Mississippi.

**multipectatus** Mall. 296, 1915a. Illinois.

**nanus** R. & H. 165, 1937. Maryland.

**niger** R. & H. 168, 1937. Maryland.

**nocivum** Harris. 602, 1862. Massachusetts.

**obsoletus** Mg. 76, 1818. United States.

*sanguisugus* Coq. 604, 1901. Maryland.

**paraensis** Goeldi. 137, 1905. Trinidad.

**phlebotomus** Will. 281, 1896. St. Vincent Island.

**piliferus** R. & H. 163, 1937. Maryland.

**pumile** Winn. See *minutissimus*.

**sanguisugus** Coq. See *obsoletus*.

**simulans** R. & H. 167, 1937. Maryland.



**scopus** R. & H. 170, 1937. Mexico.  
**sordidellus** Zett. 820, 1838. Greenland.  
**spinosus** R. & H. 172, 1937. Maryland.  
**stellifer** Coq. 604, 1901. District of Columbia, United States.  
**transiens** Walker. 25, 1848. Canada.  
**trinidadensis** Hfm. 286, 1925. West Indies.  
**tristriatulus** Hfm. See *cockerelli*.  
**unicolor** Coq. 65, 1905. California.  
**variipennis** Coq. 602, 1901. United States.  
**villosipennis** R. & H. 165, 1937. Maryland.  
**venustus** Hfm. 290, 1925. Northeastern United States.  
**yukonensis** Hfm. 291, 1925. Alaska.

Numerous South American species.

*Diplosella* K. (1921b), and *Oxyhelea* K. (1921b), genera not yet recorded from the Americas, differ from *Culicoides*, the first in having the scape and pedicel of the antenna of about equal size, the second in having a tooth laterally at the base of the first palpal segment.

#### CERATOPOGON GROUP

##### *Alluaudomyia* Kieffer (1913b)

Synonyms: *Neoceratopogon* Mall., 1915b; *Prionognathus* C. I. & M., 1921; *Thysanognathus* I. & M., 1922; *Isoecacia* Garrett, 1925.

**needhami** Thom. 287, 1935. New York.  
**splendida** Winn. 47, 1852. Eastern United States.  
*bella* Coq. 87, 1902a. District of Columbia.  
*poeyi* Garrett. 9, 1925. British Columbia.

##### *Brachypogon* Kieffer (1899)

Synonym: *Trishelea* K., 1924b.

**impar** Joh. 223, 1938. Puerto Rico.

##### *Ceratopogon* Meigen (1803)

Synonyms: *Helea* Meigen, 1800; *Psilohela* K., 1915.

**borealis** K. 68, 1919a. Greenland.  
**culicoidithorax** Hfm. 156, 1926a. New York.  
**lacteipennis** Zett. 3639, 1850. Greenland.  
**mallochi** Cole. (?). 213, 1921. Oregon. (Not a *Hartomyia*.)

A few of the earlier North American species (*C. bahamensis* Johnson, 1908, *lotus* Will., 1896, and *scutellatus* Say, 1829) and a number of South American species recorded under *Ceratopogon*, belong elsewhere but are too briefly described to place.

##### *Isohelea* Kieffer (1917a)

Synonym: *Anakempia* K., 1924c.

**stigmalis** Coq. (?). 86, 1902a. New Mexico.

*Fanthamia* deM. (1939), a South African genus, belonging to this group, and related to *Alluaudomyia*, differs in having short terminal antennal segments in the male and in the second radial cell of the wing being obliterated by coalescence of boundary veins. The wings are marked and the macrotrichia are abundant.

## STILOBEZZIA GROUP

**Diaphanobezzia** Ingram and Macfie (1931)

*D. pellucida* I. & M., the genotype, is recorded from Bariloche, Argentina. No North American species have as yet been described.

**Isthmohelea** Ingram and Macfie (1931)

*I. disjuncta* I. & M., the genotype and paratypes, are from Casa Pangué, South America. No North American species have been described.

**Stilobezzia** Kieffer (1911a)

Synonyms: *Hartomyia* Mall., 1915a; *Neostilobezzia* Goetg., 1934.

**antennalis** Coq. 606, 1901. District of Columbia, eastern United States.

**bullae** Thom. 289, 1935. New York.

**coquilletti** K. 308, 1917a.

*picta* Coq. 60, 1905. Virginia, Illinois.

**diversa** Coq. 607, 1901. New Jersey.

**lutea** Mall. 18, 1918a. Illinois.

**mallochi** Cole. 213, 1921. Oregon. (See *Ceratopogon*; certainly not *Hartomyia*).

**mallochi** Hfm. 283, 1924. New York, eastern United States.

**pallidiventris** Mall. 344, 1915a. Illinois.

**picta** Coq. See *coquilletti*.

**sequax** Will. See *Atrichopogon*.

**uncinata** Joh. Alabama. (See page 761.)

**viridis** Coq. 607, 1901. New Jersey.

A number of South American species.

**Eukraiohelea** Ingram and Macfie (1921)

**elegantula** Joh. 109, 1908b. Kansas.

*E. amnigena* Macfie from Brazil (1935a).

**Acanthohelea** Kieffer (1917b)

*A. guianae* Macfie from British Guiana.

**Serromyia** Meigen (1818)

Synonyms: *Prionomyia* Stephens, 1829; *Ceratolophus* K., 1899; *Ceratolophana* Strand, 1926; *Johannseniella* (Will.) K., 1907.

**crassifemorata** Mall. 217, 1914d. Illinois, New York.

**femorata** Meigen. 28, 1804. Northeastern United States.

**Monohoelea** Kieffer (1917a)

Synonym: *Allohelea* Kieffer, 1917a.

**maculipennis** Coq. 64, 1905. Florida.

**nebulosa** Coq. 606, 1901. New Jersey, Massachusetts, Idaho.

**tessellata** Zett. 3642, 1850. Alabama.

Sp. California.

*M. hieroglyphica* K. (1917) from Paraguay, and *M. multilimeata* Lutz (1914) from Brazil.

**Schizohoelea** Kieffer (1917a)

**polita** Coq. 606, 1901. Massachusetts, New York.

? *leucopesa* Meig. 29, 1804.

**Macrurohoelea** Ingram and Macfie (1931)

A South American genus including the genotype *M. caudata* I. & M. and *M. thoracica* I. & M.

**Pseudobezzia** Malloch (1915a)

Synonym: *Allobezzia* Kieffer, 1917a.

**expolita** Coq. 600, 1901. New Jersey.

One species (*A. brevicornis* K., 1917) from Paraguay.

**Parabezzi** Malloch (1915a)

**inermis** Coq. 86, 1902a. Arizona. (*Probezzi*?).

**petiolata** Mall. 359, 1915a. Illinois.

Also belonging to the *Stilobezzia* group are the following:

*Kiefferomyia* Mayer (1937a) having microtrichia on the wing surface, only one anterior radial cell; fourth tarsal segment not bilobed, and claws of the four anterior legs of the female all equal. A European genus.

*Luciamyia* deMeillon (1937). Wing with microtrichia; costa extending to the wing tip where it is joined by the radius; two anterior radial cells; claws of female all equal. A South African genus.

MACROPEZA GROUP

**Paraphoconus** Enderlein (1912)

This is a South American genus with *P. angustipennis* Endr. for the genotype. There are a few other recently described species from South America.

Other genera belonging to this group, all from the old world, are characterized by their long and narrowed wings, in some cases pointed at the tip, and usually with but a single anterior radial cell.

*Pellucidomyia* Macfie (1939c) from Africa lacks microtrichia on the wing surface.

*Tetrabezzi* K. (1917a) from India and Africa, has a very short crossvein bringing the radius and the media very close together at the base. The fourth tarsal segment of the four anterior legs and in two bifid lobes each armed with a spine. The genus may belong in the *Palpomyia* group.

*Calyptopogon* K. (1910) from the Orient, has an elongate crossvein which leaves the bases of the radius and the media well separated; the costa is produced well beyond the end of the posterior branch of the radius; the single anterior radial cell is very narrow; the thorax is pointed in front extending well over the head, and the anterior femora are thickened at the apex.

*Macropeza* Meigen (1818) from Europe and the Orient, resembles *Calyptopogon* but differs in having the thorax bluntly conical in front,

and in not having the femora thickened at the apex. The apex of the wing is rounded.

*Haasiella* K. (1913a) from India differs from *Macropeza* in having the apex of the wing more or less pointed.

*Macroptilum* Becker (1903) from Africa differs from the three preceding in having the costa only slightly produced beyond the tip of the radius and with apical part of the radial cell moderately wide. Either one or two anterior radial cells present.

#### PALPOMYIA-BEZZIA GROUP

##### *Stenoxenus* Coquillett (1899)

*johnsoni* Coq. 60, 1899. New Jersey.

A few South American species.

##### *Jenkinshelea* Macfie (1934)

Synonym: *Jenkinsia* Kieffer, 1913a; not *Jenkinsia* J. & E., 1896.

*albaria* Coq. 308, 1895. Florida, eastern United States.

*magnipennis* Joh. 268, 1908a. New York.

Kieffer's species *boliviensis* from Bolivia, assigned to this genus, belongs in the genus *Palpomyia*.

##### *Neurohelea* Kieffer (1925c)

*macroneura* Mall. 337. 1915a. Kansas.

Sp. California, Georgia.

A few South American species.

##### *Heteromyia* Say (1825)

Synonym: *Pachyleptus* Walker, 1856.

*clavata* Will. 224, 1900. Mexico.

*fasciata* Say. 80, 1825. Eastern United States.

*festiva* Loew. 314, 1861. Pennsylvania, New Jersey, Maine.

*pratti* Coq. 88, 1902a. Virginia, eastern United States.

A few South American species.

##### *Clinohelea* Kieffer (1917a)

*bimaculata* Loew. 311, 1861. District of Columbia, eastern United States.

*curriei* Coq. 62, 1905. British Columbia.

*dimidiata* Adams. 27, 1903. Arizona.

*nebulosa* Mall. 322, 1915a. Eastern United States.

*nubifer* Coq. 61, 1905. Florida.

Two South American species.

##### *Echinohelea* Macfie (1940c)

Three species from British Guiana.

##### *Dicrohelea* Kieffer (1917a)

*annulicornis* Mall. 230, 1918b. Illinois.

*argentata* Loew. 310, 1861. District of Columbia, eastern United States.

**Homohoelea** Kieffer (1917a)

One South American species.

**Johannsenomyia** Malloch (1915a)

Synonyms: *Johannseniella* auct. in part; *Sphaeromyias* K. nec Stephens.

**aequalis** Mall. 336, 1915a. Illinois, New York.

**albibasis** Mall. 315, 1915b. Illinois.

**caudelli** Coq. 63, 1905. District of Columbia, eastern United States.

**flavidula** Mall. 230, 1914d. Illinois.

**halteralis** Mall. 338, 1915a. Illinois.

**longicornis** Will. 280, 1896. St. Vincent Island.

**magna** Coq. 61, 1905. Texas.

A few South American species.

**Sphaeromyias** Stephens (1829)

Synonyms: *Xylocrypta* K., 1899; *Schizodactylus* I. & M., 1921; *Ankistrodactylus* I. & M., 1922.

**longipennis** Loew. 313, 1861. Pennsylvania, eastern United States.

**schwarzii** Coq. 605, 1901. Texas, Illinois, Missouri.

One species from Brazil.

**Palpomyia** Megerle in Meigen (1818)

Synonyms: *Apogon* Rond., 1856; *Alasion* Rond., 1857.

**aldrichi** Mall. 326, 1915a. Idaho, California.

**basalis**. See *flavipes*.

**cressoni** Malloch. 327, 1915a. Pennsylvania.

**flavipes** Meigen. 28, 1804. Northeastern United States.

*basalis* Walker. 27, 1848. New York.

*flaviceps* Joh. 268, 1908a. New York.

**hirta** Mall. 330, 1915a. Illinois.

**illinoensis** Mall. 218, 219, 1914d. Illinois, New York.

*illinoisensis* Mall. l. c.

**lineata** Meig. 30, 1804. New Jersey.

**opacithorax** Mall. 329, 1915a. Illinois.

**plebeia** Loew. 313, 1861. Northeastern United States.

**pruinescens** Thom. 290, 1935. New York.

**rufa** Loew. 314, 1861. Northeastern United States.

**scabra** Coq. 62, 1905. Mexico.

**slossonae** Coq. 61, 1905. New Hampshire.

**subasper** Coq. 606, 1901. United States.

**tenuicornis** Mall. 328, 1915a. Wisconsin.

**tibialis** Meigen. 82, 1818. Northeastern United States.

**trivialis** Loew. 309, 1861. Northeastern United States.

Numerous species from South America.

**Lasiobezzia** Kieffer (1925b)

**unica** Joh. 345, 1934. New York.

**Ceratobezzia** Kieffer (1917a)

*C. fallax* K. from Paraguay and *C. flavida* Joh. from British Guiana.

**Dicrobezzia** Kieffer (1919a)

**smithi** Coq. 600, 1901. New Jersey, northeastern United States.

**xanthogaster** K. 1917a.

*elegans* Coq. 599, 1901. New Jersey, northeastern United States.

**Bezzia** Kieffer (1899)

**albidorsata** Mall. 349, 1915a. Illinois, Virginia.

**apicata** Mall. 284, 1914c. Illinois.

**banksi** Gerry. 94, 1933. Cuba.

**barberi** Coq. 601, 1901. Maryland.

**cockerelli** Mall. 346, 1915a. Colorado.

**dentata** Mall. 284, 1914c. Illinois.

**flavitarsis** Mall. 283, 1914c. Illinois.

**johnsoni** Coq. 600, 1901. New Jersey.

**media** Coq. 166, 1904b. New Jersey.

**pruinosa** Coq. 59, 1905. British Columbia.

**pulverea** Coq. 600, 1901. Northeastern United States.

**setipes** Coq. 59, 1905. Texas.

**setulosa** Loew. 312, 1861. District of Columbia, northeastern United States.

**varicolor** Coq. 84, 1902b. New York.

**venustula** Will. 278, 1896. St. Vincent Island.

Several South American species.

**Probezzia** Kieffer (1906a)

**albiventris** Loew. 311, 1861. Eastern United States.

**bivittata** Coq. 60, 1905. California.

**copiosa** Thom. 292, 1935. New York.

**flavonigra** Coq. 60, 1905. British Columbia.

**fulvithorax** Mall. 354, 1915a. Illinois, Michigan.

**gibber** Coq. 60, 1905. Cuba.

**glabra** Coq. 85, 1902a. Florida, eastern United States.

**incerta** Mall. 358, 1915a. Illinois.

**inermis** Coq. 86, 1902a. Arizona. (Cf. *Parabezzia*.)

**infuscata** Mall. 316, 1915b. Illinois.

**obscura** Mall. 356, 1915a. New York.

**opaca** Loew. 312, 1861. District of Columbia, New Jersey.

**pachymera** Will. 224, 1900. Mexico.

**pallida** Mall. 138, 1914b. Northeastern United States.

**punctipennis** Will. 278, 1896. St. Vincent Island.

**terminalis** Coq. 90, 1904a. Nicaragua.

A few South American species.

**Homobezzia** Macfie (1932a)

One South American species.

**Parrotia** Kieffer (1924a)

One South American species.

A number of genera belonging to the *Palpomyia*-*Bezzia* group and not yet recorded from the Americas are briefly defined below. Of these

the first three have a wing venation resembling that of *Palpomyia* with two anterior radial cells; the remainder have a *Bezzia*-like venation with but a single anterior radial cell.

*Metahelea* Edwards (1929). Tarsi with the fourth segment ending in two bifid lobes, the lower lobe on each side bearing a spine; fifth segment unarmed; femora armed. Claws of the female on at least the posterior legs unequal (perhaps only one present on each foot). A Philippine genus.

*Xenohela* Kieffer (1917a). Syn.: *Mixohela* K. (1917a). Tarsi of fifth segment armed with blunt spines and not swollen; claws unequal and simple on all legs; femora armed, not much swollen. Oriental and Australasian species.

*Dibezzia* Kieffer (1911a). Abdomen petiolate; claws of female all unequal and barbed; fourth tarsal segment cylindrical; fifth armed; femora unarmed. India.

*Tetrabezzi* Kieffer (1917a). Tarsi of the four anterior legs ending in two bifid lobes as in *Metahelea* above; fourth segment of hind legs long, cylindrical; claws of the female unequal and simple; fore femora armed; hind legs very long. India and Africa. See *Macropeza* Group.

*Nilobezzia* Kieffer (1921b). Femora without stout spines, but those of the four posterior legs armed with longer spinose bristles; fifth tarsal segments armed; fourth tarsal segment subcylindrical; claws of female equal and barbed. Africa and E. Indies.

*Crepinia* Kieffer (1924a). Resembles *Parrotia* but the fifth tarsal segments are unarmed, palpi very short; antennae of male with intermediate segments bearing three or four whorls of hair. East Indies.

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## BOOK NOTICES

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**BIOLOGY AND CONTROL OF COMMON BLISTER BEETLES IN ARKANSAS**, by WILLIAM R. HORSFALL. Pages 1-55, 11 figures and 34 tables, 6 x 9 inches, paper bound. Bulletin No. 436, University of Arkansas College of Agriculture, Agricultural Experiment Station, Fayetteville, Arkansas, 1943.

This bulletin deals with the life history, habits, and control of seven species of blister beetles. The major portion of the paper contains very complete data on the biology of the various species. The principal control measures recommended are the control of the grasshopper hosts of the beetle larvae, and the use of fluosilicate or rotenone dusts against the adult beetles. This is an excellent account of a group of insects which are occasionally very destructive to garden and field crops.—D. J. B.

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**DIE THYNNIDEN CHILES**, by LEONIDAS DURAN-MOYA, 1941. Pages 71-176 in *Archiv Naturg.* N. F. Bd. 10, Heft 1.

The ANNALS has just received from Chile the above recently published monograph. Dr. Durán-Moya is on the staff of the Sección Zoología Agrícola del Depto. de Sanidad Vegetal, Santiago.

The study is based largely on collections in Berlin and Vienna and was done just before the present collapse of European civilization. We notice it because it constitutes a distinct contribution from Chile and particularly because it deals with a family of parasitic wasps, with wingless females which parasitize burrowing larvae, a primitive family of Hymenoptera which has the interesting distribution of marsupial mammals. It is well represented in Australia and has scattered outlying species in Luzon, New Caledonia and in the Americas in California. Its distribution is paralleled by the distribution of a whole series of animals. A very primitive family of Odonata is so distributed and many other groups have series of species in the Chilean Andes and Australia and New Zealand. Are they the representatives of a lost Antarctic fauna or are they the extreme tips of a Polar Radiation Distribution? We wonder.

The work is well illustrated for a paper on Hymenoptera. About sixty forms are keyed and described but as the author points out, the temperate areas of Peru have been poorly explored for species in the northern range of the group.

—C. H. K.

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**A REVISION OF NEARCTIC DORILAIIDAE (PIPUNCULIDAE)**, by D. ELMO HARDY. University of Kansas Science Bulletin, 29 (1): 1-231, 464 figs., 6½x9½ inches, paper bound. 1943. UNIVERSITY OF KANSAS PUBLICATIONS, LAWRENCE, KANSAS.

This paper is a monographic study of all the known Nearctic species of the family, and brings up to date the taxonomy and known data concerning these flies. It contains keys to the subfamilies, genera, and subgenera of the world, and keys to Nearctic genera and species. Fourteen world genera and one subgenus are described; one genus is described as new; 117 species, subspecies, and varieties are described, 27 of which are described as new. There are a number of changes in nomenclature and synonymy. The figures illustrate all the important taxonomic and morphological characters.

The introductory portion of this paper (pp. 1-24) contains discussions of the taxonomy, morphology and terminology, biology and economic importance, and the methods of study. The writer has done extensive field work on these flies, and has examined all the available types of the North American species. The taxonomic work has been carefully and thoroughly done; the keys, descriptions, and illustrations are excellent, and leave nothing to be desired. This paper should prove a stimulus to further study of the biology of this important group of parasitic flies.—D. J. B.

VEINTICINCO ESPECIES NUEVAS DE TROMBIDIIDEOS EN COLOMBIA, by JORGE BOSHELL and J. A. KERR, 1942. Revista Academia Colombiana de Ciencias 5(17): 110-127, 51 text figs. and 2 pls. Bogota, Colombia.

This paper figures and describes (in Spanish) twenty-five mites of the genera *Trombicula*, *Neoschongastia*, *Manriquea* (gen. nov.), *Microtrombidium*, *Allotrombidium* and *Moyanella* (gen. nov.). Type material is deposited in the U. S. National Museum. It is another evidence of the vigor of biological research in South America. The authors are on the staff of the Laboratorio de la Seccion de Estudios Especiales del Ministerio de Trabajo, Higiene y Prevision Social de Colombia, Bogota.—C. H. K.

PORTRAITS OF KENTUCKIANS, by W. D. FUNKHOUSER, 1943; 102 pages, green cloth binding. Privately published, Lexington, Kentucky.

This very entertaining picture of archaeological work on the rock shelter inhabiting Indians of central Kentucky is of interest to entomologists as it is by our leading expert on the Membracidae, at present Dean of the Graduate School of the University of Kentucky.

It is fiction from cover to cover. In it are given biographic sketches of Kaloom, the first Indian explorer of central Kentucky; Oneeka, the beautiful cave maiden; Zug, the medicine man; Yakoot, the mound builder; and Sagamak, the hunter. With the purely imaginary tales as a frame, an interesting and accurate picture of archaeological study of the region is given. It covers the dry bones from cave burials from Indian mounds and from kitchen-middens with flesh and blood and leads the individuals through everyday Indian life of normal human motivation. It is a clever attempt to give nonarchaeologists a sound picture of Indian life in Kentucky's pre-julep and pre-poker days, before that hunter's paradise was despoiled by race horses, Colonels and lovely women.

The writer of this notice studied at Cornell for two years desk to desk with Funkhouser when candidate for his Doctor's degree in entomology. He has done that thing in the writing of this book that only too few American entomologists would have dared to do. He has risked his reputation as a scientist, but he has accomplished that which "scientific" archaeological exposition could not have done. He has given sound archaeology to the layman.

Funkhouser is one of the few men we have known who is devoid of fear, a champion collegiate wrestler as a student, a nationally known umpire in that sport in graduate days, always unruffled. Always willing to accept responsibility but never scheming for that next more distinctive title. He did not succumb to that mild form of insanity, the plague of individualistic democracy (?), which in entomology expresses itself in a burning desire to put one's name on one more new species, to be head of the department, or (may I word it without rising to attention) to be a Dean. Future reputation never seemed to bother him. He worked out with great thoroughness whatever was the job in hand at the time, and was content in work done as thoroughly as his ability and hard work permitted.

Fearlessness to the point of daring is shown in the present volume by the introduction on page 38 of an anachronism any high school student would catch which may have been introduced to check on his readers. The author "will be told" by his friends. Obviously we have enjoyed "Portraits of Kentuckians."

C. H. K.

NATURALIST AT LARGE, by THOMAS BARBOUR. Pages xii and 314, 23 plates, 1943. Published by the ATLANTIC MONTHLY PRESS (LITTLE, BROWN AND Co.), 34 Beacon St., Boston, Mass. Price \$3.50.

We have known Thomas Barbour for years, but only through the admiring comments of mutual friends. Once we shook hands. He is at least six and a half feet tall and stood on Harvard steps above us. But what we remember even more vividly than his stature was the gracious smile.

The gracious smile is on every page of Naturalist at Large. The book's subtitle could well have been "Work and Travel among Friends!" It is autobiography from the very interesting Barbour family to the author's present con-

nection with the organization and ideals of the brilliant staff of the Agassiz Museum and its connections, the whole of which forms the Museum of Comparative Zoology. Naturalist at Large is a mental therapeutic, a psychic vitamin, which restores a bug-catcher's self respect, particularly after he has lunched with serious faculty men whose grave conversation has been ornate with "conferences," "committees," "budgets" and "important meetings." After reading Barbour, insects have resumed importance and the entomologist is again one of a clan of scientific workers in a field of social significance.

The style puzzles one at first. Parts have appeared in the *Atlantic Monthly*. But after a few pages you realize it is Barbour himself. He writes as spontaneously as he thinks. The style pictures the character of the author. The general design is popular. It is a series of chapters on trips to strange and interesting places, of chapters on scientific ideals, on personal pleasures and personal sorrows. It never lags but passes swiftly from highlight to highlight of action and observation during a rich and varied experience in two hemispheres. Perhaps emphasis is on animal and plant life of the Neotropics and Harvard connections with neotropical biology. Barbour helped organize the Harvard Botanical Garden at Soledad, Cuba, the Barro Colorado Laboratory at Panama, an Antivenin Institute for the United Fruit Company in Honduras and worked on the board which chose U. S. and South American students for Guggenheim Scholarships. Since 1927 he has been Director of the Museum of Comparative Zoology. His research has been on reptiles. As a collector of world-wide experience he is fluent in Spanish and gets about in Dutch, Malay and Portuguese. But through all the narrations the charm of the text is in the passage from friendship to friendship.

Barbour lives in a world of friends. The total forms a picture of Tom Barbour as reflected in experiences in strange places, in stimulating interests and particularly in lasting friendships. Naturalist at Large is a narrative of those choicest of all living experiences, friendships. As anticlimax: the reviewer has read the volume word for word from cover to cover.—C. H. K.

GUIDE TO THE INSECTS OF CONNECTICUT. PART IV. THE DIPTERA OR TRUE FLIES OF CONNECTICUT. FIRST FASCICLE. EXTERNAL MORPHOLOGY; KEY TO FAMILIES; TANYDERIDAE, PTYCHOPTERIDAE, TRICHOCERIDAE, ANISOPODIDAE, TIPULIDAE. By GUY C. CRAMPTON, CHARLES H. CURRAN, CHARLES P. ALEXANDER, and ROGER B. FRIEND. Pages x + 509, 4 plates and 55 text figures, 6x9 inches. Connecticut State Geological and Natural History Survey, Bulletin No. 64, 1942. Available from Distribution and Exchange Agent, James Brewster, State Library, Hartford, Conn. Price, \$2.25.

This bulletin begins the sixth order of insects to be treated in the Guide to the Insects of Connecticut. The Euplexoptera and Orthoptera were covered by Part II (1911), the Hymenoptera by Part III (1916), the Hemiptera by Part IV (1923), and the Odonata by Part V (1927).

Like most of the previous volumes, this one is a compilation by several authors: the Introduction (pp. 1-9) is by R. B. Friend; The External Morphology of the Diptera (pp. 10-165, figs. 1-14) is by G. C. Crampton; Wing Venation (pp. 166-174, figs. 15-17) is by R. B. Friend; Key to Families (pp. 175-182) is by C. H. Curran; the treatment of the five tipuloid families (pp. 183-486, figs. 18-55) is by C. P. Alexander.

The key to families includes all of the families at present known from this continent. The treatment of the five families contains keys to genera and species and gives for each species a synonymy, a list of references in the literature containing figures of the species, a brief description, and a statement of the species' seasonal and geographic distribution. There are a great many figures illustrating specific characters. There is a very complete index (pp. 487-509), which is divided into two sections—Morphology and Taxonomy.

The outstanding feature of this bulletin is the section on external morphology. This paper is probably the best of Dr. Crampton's many papers on insect morphology. It is very complete, well illustrated, and contains an extensive bibliography. The value of the bulletin to entomologists generally is greatly enhanced by this section.—D. J. B.

## CRITERIA FOR VERTEBRATE SUBSPECIES, SPECIES AND GENERA.

(A symposium) by CHARLES M. BOGERT, W. FRANK BLAIR, EMMETT REID DUNN, E. RAYMOND HALL, CARL L. HUBBS, ERNST MAYR, and GEORGE GAYLORD SIMPSON, 1943. *Annals New York Academy of Sciences*, vol. 44(2): 107-188. Address: Central Park West at 79th St., New York City. Price \$1.00.

This series of essays by taxonomists, each expert in a different group of vertebrates, will be of interest to students of insect taxonomy. In no two vertebrate groups are species looked upon from quite the same point of view. The palaeontologist never thinks in terms of physiological species. His species based on bones no longer live. The expert on fishes thinks in numerous anatomical variables because fin rays and scales can be counted easily while fish can be collected in large numbers by net and dynamite. The student of mammals deals with a minimum of forms and has time to breed and hybridize. The student of birds tends to resort to distribution over chains of islands or along ranges of mountains to show how species evolve under restricted distribution.

This series of expert essays is of particular value because of the above differences of view due of necessity to the diverse materials for study, and is interesting because we have the views of some of the leading experts in America on the subject. As Hubbs has shown even some well differentiated genera, so called, of fishes can cross and produce stable hybrid populations and what have we? As a prominent student of the subject of speciation recently remarked to the reviewer, we may have to forget the term species, call them populations and describe them statistically.

No summary of views is given but the reader is left with the idea that taxonomic descriptions are too nearly wholly morphological. Mayr (p. 135) points out that species as interbreeding populations in nature with definite distributions were recognized by the intelligent nonscientific public before the binomial nomenclature was invented by John Ray and later by Linnaeus. The taxonomic description and the accompanying binomial Latin name were given to displace the colloquial names which varied from place to place and country to country. The group names (genera) and stabilized species names made a system which facilitated the comparative study of living forms. The easiest and most directly usable characters were naturally morphological. For brevity's sake other characters were omitted. Then the followers made a religion of what the masters had used for convenience. Only morphological characters were proper. As Mayr says, "morphological characters are of practical convenience but not a primary criterion." Because morphological characters are always present and generally usable, while the true species distinction, the genes of the interbreeding population, disappears in the museum, taxonomy early in its development put the cart before the horse and insisted on morphological distinctions in species descriptions.

Against this clear-cut view of Mayr (in birds), Hubbs (in fishes) cites two genera of fishes which interbreed in nature and produce hybrid species; while Dunn (in amphibia) cites two populations of frogs, identical morphologically, which occupy the same general territory but resort to different waters to breed and which have different calls. To Mayr the two hybridizing genera of fishes would probably form one species of two subspecies and a third hybrid subspecies. The two populations of frogs identical in any museum would be two good species.

Subspecies are given the same critical examination.

The genus suffers the most. It comes through the mill of pointed examination stripped of even honorable mention. With the splitter it becomes monotypic, with the lumper all inclusive. It is obviously a term of convenience in the hands of the temperate taxonomist, supposedly an indication of interspecies relationship.

The series of essays makes an entomologist accustomed to describe a species on one specimen of one sex hesitate. Has he helped his science? If a species maker of the third or higher degree of taxonomic intoxication, has he helped his reputation when his name resounds down the corridors of time tied onto the end of one type specimen? The palaeontologists do it for merely one bone, but bones have a disturbing rattle whether dragging an author's name along or not.

We recommend this symposium, given before a joint meeting of the American Society of Ichthyologists and Herpetologists and the American Society of Mammalogists at the American Museum of Natural History in 1942, to all students of insect species for a brief and condensed statement of present views of criteria for subspecies, species and genera.—C. H. K.



AN INTRODUCTION TO BIOPHYSICS, by OTTO STUHLMAN, JR. Pages vii + 375, 154 illustrations, 6x9 inches. Published by JOHN WILEY & SONS, INC., New York. 1943. Price, \$4.00.

Some knowledge of animals can be obtained by observing their processes and reactions, but this knowledge cannot be complete without an understanding of both the chemical and physical phenomena involved. The ideal approach to a biological problem is one which combines the facts of anatomy, physiology, and behavior with the related principles of chemistry and physics. Entomologists, particularly those in the field of ecology and physiology, need an understanding of these basic sciences.

This book has been written with the hope that it may lead to a fuller appreciation and understanding of the applications of physical principles to biological problems. It is concerned with the methods and principles of physics in the fields of radiant energy and optics, surfaces and membranes, nerve conduction, sound and hearing, and optical and electron microscopy.

The first two chapters of the book deal with the nature and source of high-frequency radiations (X-rays, gamma rays, etc.), radioactivity and its applications (including the use of radioactive tracer elements), and the biological effects of these radiations. Chapter 3 deals with the biophysical characteristics of the eye, particularly the human eye. Chapter 4 deals principally with the nature and effects of ultraviolet radiation. Chapter 5 discusses the structure and properties of surfaces and membranes, osmosis and related phenomena, and the relationship of these to the living cell membrane. Chapter 6 discusses the problem of nerve conduction, including the field of bioelectric measurements by means of vacuum-tube amplification technique and the modern cathode-ray oscillograph. Chapter 7 deals with sound and hearing, and the fundamental physical principles involved. Chapter 8 discusses the problem of microscopy, and the principles involved in the use of both the compound and electron microscopes. The book is well illustrated, and there is a bibliography at the end of each chapter. At the end of the book is a table of physical constants, a list of problems (with answers given), and name and subject indices.

Although this book is concerned with the biophysics of man, it should be of value to entomologists as a source of information not only on the physical principles which relate to animal biology, but on techniques which the entomologist can use. We recommend it to all entomologists interested in the applications of modern physics to their work.—D. J. B.

THE CARNIVOROUS PLANTS, by FRANCIS ERNEST LLOYD. 'Pages xv and 352, 11 text figs., 38 pls. Linen, large octavo. Published as Vol. IX in A New Series of Plant Science Books by the CHRONICA BOTANICA COMPANY, Waltham, Mass. Also G. E. STECHERT Co., New York City. Price, \$6.00.

From the introduction: "The purpose of this book is to give an historical review and summary of our present knowledge about carnivorous or insectivorous plants. Of these there are about 450 or more, representing 15 genera, belonging to six families."

"*Roridula*, formerly regarded as carnivorous, has now been shown not to be so. The 'man-eating tree of Madagascar' must at present be excluded, since the evidence of its existence is elusive. Carnivorous plants are divisible into two groups. This wide separation indicates that the carnivorous habit has arisen at two points at the fewest (as well as among the fungi)."

Fifteen genera supply material for fourteen extensive chapters: I. *Heliophora* (Mt. Roraima, Brit. Guiana); II. *Sarracenia* (E. U. S. and Canada); III. *Darlingtonia* (Ore., Calif.); IV. *Nepenthes* (East Indies, Madagascar); V. *Cephalotus* (West Australia); VI. *Genlisea* (West Africa, Neotropics); VII. *Byblis* (West Australia); VIII. *Drosophyllum* (Morocco, Spain); IX. *Pinguicula* (Holarctic); X. *Drosera* (World-wide); XI. Carnivorous Fungi; XII. *Dionea* (N. and S. Carolina), *Aldrovanda* (France to Japan to Australia); XIII. *Utricularia* (America, Africa), *Biovularia* (Cuba, Brazil), *Polypompholyx* (West Australia); XIV. The *Utricularia* Trap.

The flowering entomophagous plants are scattered through six families three of which are familiar to American naturalists, *Sarraceniaceae* (pitcher plants), *Droseraceae* (screw-leaf traps, etc.), *Lentibulariaceae* (active bird-lime traps,

mouse trap type). The fungi include those which spread nets of hyphae through the wet soil or stagnant water. Loops are developed. When an eelworm attempts to crawl through one such, the loop suddenly clamps down and later send branches into the body of its victim. The empusid fungi are not included as, while entomophagous, they set no traps.

Carnivorous Plants is interesting for various reasons. It is in that class of expository literature, classed by newspaper men as news ("When a man bites a dog"). Plants do not commonly trap and eat animals. The author has an easy style and is not dependent on an array of technical terms though such are used properly when needed.

The anatomy of the many and varied traps is shown in the thirty-eight plates which are mostly excellent detailed drawings. The illustrations are so many and so clear that one could almost read the book by looking through the plates. Such a reader would miss the extensive notes on distribution and the review in each chapter of previous work on particular species.

Professor Francis Ernest Lloyd, recently retired as Emeritus Professor of Botany, McGill University, has had about as many high positions and honors in the field of botany as are accorded to one scientist. An Englishman by birth, a graduate from Princeton with study in Munich and Bonn he later taught at Columbia University, was at the Desert Laboratory of the Carnegie Institution of Washington, later in rubber-plant studies for the Continental-Mexican Rubber Company (guayule rubber), at Alabama Polytechnic Institute (studying boll-shedding of cotton), then at McGill University.

Carnivorous Plants is the product of an interest that began in 1929 and which included many years of world correspondence to obtain material for the study. For a man with less drive it could represent a life-time of research.—C. H. K.

**BIOLOGY: THE SCIENCE OF LIFE**, by MARY STUART MACDOUGALL in collaboration with ROBERT HEGNER. Pages x and 963, 1943. 9 x 6 inches. Published by MCGRAW-HILL BOOK CO., INC., New York. Price, \$4.00.

The outstanding feature of this book is the breadth of its biological view. We have never thought well of tightly pigeon-holed courses that give a beginning student the idea that zoology is something utterly different from botany, that entomology is something vastly superior to zoology, or that chemistry is over in some other world. As Ohio State University entomology is but one branch of a four-branch department that encompasses zoology, entomology, parasitology, and genetics. At this institution we have insisted that the graduate students in entomology fill in their schedules with courses in plant physiology, animal physiology, plant ecology, animal ecology, genetics, agricultural chemistry, organic chemistry, physics, biomathematics, and such. After 25 years we are just beginning to realize that such students as had the ability to profit by this variety of training are the students who have stepped forward and gone on to further development after leaving the University. They have the broad foundation which helps them to comprehend new problems that arise.

The broad scope of this volume is indicated by its table of contents: Introduction; Part I, The Foundations of Biology (7 chapters); Part II, Plant Biology (6 chapters on the morphology and physiology of a seed plant, 3 chapters on the plant groups and their representatives); Part III, Animal Biology (1 chapter on the frog as a typical vertebrate, 16 chapters on the animal groups and their representatives); Part IV, General Biology: Organ Systems and Their Functions, and the Biology of Man (10 chapters); Part V, Some Biological Principles and Theories (4 chapters, on germ cells and fertilization, variation and heredity, adaptations, and descent with change or evolution); Part VI, Applied Biology, Biology and Human Welfare, and Conservation (2 chapters); Part VII, The History of Biology (1 chapter). At the end of the book there is an appendix (containing a synopsis of ecological communities, a chart of the cranial nerves in vertebrates, a table on the composition of foods, and an outline on the faunal regions of the world), a glossary (of 26 pages), and an index. There are 555 illustrations; all are good, and many are original. At the end of each chapter is a list of questions for study, and a list of suggested references.

While in the main we like the organization and presentation of the subject matter in this text, certain parts of it are disappointing. Some of the sections

are conspicuously out of date. The chapter on evolution might have been written about 15 years ago; it is concerned mainly with the "evidences" of evolution (classification, comparative anatomy, embryology, paleontology, etc.) and the various "theories" as to the methods of evolution (e.g., those of Lamarck, Darwin, Weismann, DeVries, etc.), and there is no concise summary of our present knowledge of how evolution takes place. The discussion in the chapter on conservation is in some respects misleading. For example, the author lists three measures for preventing erosion: terracing, establishment of woodlands, and permanent pastures; the most fundamental principles of erosion control are omitted: proper land use (i.e., level or rolling land for cultivation, hilly land for meadows and pastures, and steep land for forests), contour cultivation and related practices, and management of permanently vegetated areas (pasture and forest), etc. Some of the governmental agencies mentioned in this chapter (C. C. C., U. S. Biological Survey, and U. S. Bureau of Fisheries) are no longer in existence, and have not been for some time. Some of these undesirable features might have been avoided if the various sections had been read critically by experts prior to publication.

This book shows the excellent workmanship, printing, and binding that are characteristic of the McGraw-Hill publications.—D. J. B.

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## CORRECTIONS (ERRORS AND OMISSIONS)

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Corrections are limited to critical omissions and serious errors.—The Editors.

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**James, M. T.** 1943. Studies in Neotropical Stratiomyidae (Diptera). V. *Annals*, 36(3): 365-379:

p. 374, the centered head "*Histriodroma tricolor* James" should read "*Histriodroma tricolor* James."

**Edwards, F. W.** 1942. Review of "Mosquitoes of the Ethiopian Region III." *Annals*, 35(4): 475.

The statement concerning Edwards' death as following an injury in a bombing raid is incorrect. He died a natural death. The correction came by letter from an officer of the Royal Entomological Society of London. Our incorrect information came from supposedly reliable British sources and was not questioned at the time.—C. H. K.

**Thonless, Robt. H.** 1943. Review of "Straight and Crooked Thinking." *Annals*, Vol. XXXVI (1): 139.

*Thonless* should read *Thouless*.

# INDEX TO VOLUME XXXVI

All new names are printed in *italics*.

- Acanthagrion adustum*, 180.  
*indefensum*, 182.  
*Acanthohelea*, 781.  
*Acentron*, 663.  
*Aconophora brevicornis*, 467.  
*caliginosa*, 465.  
*coffea*, 466.  
*disparicornis*, 465.  
*ensata*, 465.  
*ferruginea*, 465.  
*laminata*, 465.  
*laticornis*, 465.  
*lutea*, 466.  
*marginata*, 465.  
*mexicana*, 465.  
*nigricornis*, 465.  
*pallescent*, 465.  
*pubescens*, 466.  
*sinanjensis*, 466.  
*temaxia*, 466.  
*Acutalis fusconervosa*, 470.  
*Adippe inaequalis*, 477.  
*zebrina*, 477.  
*Adoxomyia*, a new genus related to, 380.  
*Aedes dorsalis*, metamorphosis of the nervous system of, 432.  
*Aenictus*, 326.  
*Aenictus (A.) aratus nesiotus fraterculus*, 326.  
*Aenictus (Typhlatta) leviceps*, 326.  
*martini*, 326.  
*Agapostemon coloradensis*, 645.  
*Alchisme grossa*, 459.  
 Alexander, C. P., Article by, 103.  
*Alluaudomyia*, 780.  
*Amastris funkhouseri*, 478.  
*pacifica*, 478.  
*Ampulex (Rhinopsis) ferruginea*, description of female, 46.  
*Analcocerus*, 367.  
*atriceps*, 368.  
*longicornis*, 368.  
*orbitalis*, 368.  
*taurus*, 370.  
*Anatomy of Grylloblatta campodeiformis*, 681.  
*Anatomy of the larva of the wasp Polistes gallicus*, 619.  
*Ancistrocerus bravo*, 534.  
*guzmani*, 534.  
*Anopheles argyritarsus*, 14.  
*Anopheles (Nyssorhynchus) sawyeri*, a new anopheline mosquito from Ceara, Brazil, 11.  
*Anthemiois*, 662.  
*Anthocopa*, 83.  
*bees of the genus*, 49.  
*key to American subgenera of*, 51.  
*Old World subgenera of*, 83.  
*Anthocopa (Atoposmia)*, 51.  
*abjecta*, 57.  
*alta*, 57.  
*anthodyta*, 60.  
*elongata*, 61.  
*malognatha*, 67.  
*mesae*, 59.  
*nigrior*, 54.  
*oregona*, 53.  
*panamintensis*, 65.  
*pynognatha*, 64.  
*shastensis*, 64.  
*triadonta*, 62.  
*triadonta triadonta*, 63.  
*triadonta usingeri*, 63.  
*Anthocopa (Eremosmia)*, 66.  
*laevibullata*, 68.  
*malognatha*, 67.  
*nidivitta*, 70.  
*robustula*, 71.  
*rupestris*, 72.  
*timberlakei*, 69.  
*Anthocopa (Hexosmia)*, 74.  
*albomarginata*, 77.  
*arefacta*, 76.  
*copelandica*, 75.  
*phaceliarum*, 74.  
*Anthocopa (Phaeosmia)*, 77.  
*enceliae*, 80.  
*hemizoniae*, 79.  
*mortua*, 78.  
*viguierae*, 80.  
*Anthocopa (Xerosmia)*, 81.  
*palmarum*, 83.  
*xerophila*, 81.  
*Antianthe chichiana*, 476.  
*expansa*, 475.  
*foliacea*, 475.  
*humilis*, 475.  
*reversa*, 475.  
*viridissima*, 476.  
*Ants, army, the larvae of*, 319.  
*Ants, population studies of two species of, Leptothorax longispinosus and L. curvispinosus*, 743.  
*Apelma*, 778.  
*Aphetea inconspicua*, 476.  
*nigropicta*, 476.  
*Araneida found on cotton in central Texas*, 257.  
*Archimegachile*, 671.  
*Argia insipida*, 172.  
*Argiallagma minutum*, 174.  
*Argyropile*, 663.  
*Army ants, larvae of*, 319.  
*Armyworm, southern: feeding habits of and rate of passage of food through its gut*, 243.

- Artucephalus*, a new genus of Mexican leafhopper, and a new species, 654.  
*Artucephalus fasciatus*, 654.  
*Aspona cuneata*, 468.  
     *turgescens*, 468.  
*Asteia*, 502.  
     *albovaria*, 502.  
     *multipunctata*, 502.  
*Asteiidae*, new genera and species of, with a review of the family in the Americas, 501.  
*Asteiidae*, check list of American, 513.  
     key to American genera of, 501.  
*Asteimyia*, 505.  
     *antennata*, 506.  
     *spinosa*, 505.  
*Astiosoma*, 512.  
     *flaveola*, 512.  
     *hirta*, 512.  
     sp. (*hirta*?), 513.  
*Atoposmia*, 51.  
     key to the species of, 52.  
*Atrichopogon*, 776.  
*Attagenus* (?) spp., some vitamin requirements of, 483.  
*Austromegachile*, 666.  
*Basentidema*, 376.  
     *coerulescens*, 376.  
     *hortulana*, 376.  
     *syrphoides*, 376.  
 Bates, Marston. Article by, 21.  
 Beerbower, Fred V. Article by, 672.  
 Bees of the genus *Anthocopa*, 49.  
 Bees, certain social and solitary, of Mexico, notes on the nesting habits of, 641.  
 Bees, stingless, 641.  
 Beetles, black carpet, some vitamin requirements of, 483.  
 Behavior, insect: how the cockroach deposits its egg-case, 221.  
 Bender, J. C. Article by, 537.  
 Bequaert, J. C. Articles by, 394, 717.  
 Bezzia, 785.  
 Biology of *Hadronotus ajax*, a parasite in the eggs of the squash-bug, 625.  
*Boethoos distinguenda*, 478.  
 Bohart, R. M. Article by, 341.  
*Bolbonota attila*, 455.  
     *cuneata*, 455.  
     *inconspicua*, 455.  
     *insignis*, 455.  
     *pictipennis*, 455.  
 BOOK NOTICES, AUTHORS:  
     Alexander, Charles P., 794.  
     Ayyar, T. V. *Ramakrishna*, 242.  
     Baerg, William J., 140.  
     Barbour, Thomas, 793.  
     Blackman, M. W., 220.  
     Blackwelder, Richard E., 249.  
     Blair, W. Frank, 795.  
     Bogert, Charles M., 795.  
     Borror, Donald J., 587.  
     Boshell, Jorge, 793.  
     Böving, Adam G., 618.  
     Cantrall, Irving J., 482.  
     Capps, Hahn W., 220.  
     Cattell, Jaques (ed.), 142.  
     Chamberlin, Ralph V., 318.  
     Charipper, Harry A., 382.  
     China, W. E., 545.  
     Costa Lima, A. da, 762.  
     Crampton, Guy C., 794.  
     Culbertson, James T., 189.  
     Curran, Charles H., 794.  
     Davis, Darrell Haug, 514.  
     Dorsey, Carl Kester, 143.  
     Douglas, J. R., 601.  
     Durán-Moya, Leonidas, 792.  
     Dunn, Emmett Reid, 795.  
     Ewing, H. E., 336.  
     Felt, Ephraim Porter, 359.  
     Fiedler, Karl, 127.  
     Fisher, W. S., 309.  
     Fox, Irving, 336.  
     Friend, Roger B., 794.  
     Funkhouser, W. D., 793.  
     Graham, Samuel A., 500, 680.  
     Hall, E. Raymond, 795.  
     Hamburger, Viktor, 364.  
     Hardy, D. Elmo, 792.  
     Hegner, Robert, 797.  
     Hobbs, Horton H., Jr., 258.  
     Horsfall, Frank L., Jr., 646.  
     Horsfall, William R., 792.  
     Hubbs, Carl L., 795.  
     Imms, A. D., 138.  
     Ivie, Wilton, 318.  
     Jellison, William L., 424.  
     Kane, Henry B., 143.  
     Kerr, J. A., 793.  
     Klages, Karl H. W., 485.  
     Kohls, Glen M., 424.  
     Kortright, Francis H., 194.  
     Kunkel, Louis O., 646.  
     Lloyd, Francis Ernest, 796.  
     MacDougall, Mary Stuart, 797.  
     Matschat, Cecile Hulse, 239.  
     Mayr, Ernst, 138, 795.  
     Medler, John T., 536.  
     Mills, Harlow B., 424.  
     Mode, Elmer B., 280.  
     Munoz, Frank J., 382.  
     Needham, Joseph, 36.  
     O'Roke, Earl C., 500.  
     Park, Orlando, 33.  
     Parshley, H. M., 545.  
     Patterson, J. T., 454.  
     Pearse, A. S., 140.  
     Poos, F. W., 655.  
     Power, Maxwell E., 431.  
     Raven, Charles E., 586.  
     Rees, Bryant E., 545.  
     Ricker, William E., 536.  
     Ritcher, P. O., 545.  
     Rivers, Thomas M., 646.

Rous, Peyton, 646.  
 Sandhouse, Grace, 220.  
 Schoof, Herbert F., 142.  
 Sellers, Wendell F., 191.  
 Shope, Richard E., 646.  
 Simpson, George Gaylord, 795.  
 Smith, Roger C., 141.  
 Snodgrass, R. E., 588.  
 Stanley, Wendell M., 646.  
 Stuhlman, Otto, Jr., 796.  
 Tehon, Leo R., 143.  
 Thomas, W. Stephen, 653.  
 Thompson, D'Arcy Wentworth, 140.  
 Thouless, Robert H., 139.  
 Tuthill, Leonard D., 739.  
 Valentine, J. Manson, 139.  
 Wheeler, Nancy H., 655.  
 Wille, Johannes E., 640.

## BOOK NOTICES, BOOKS:

Amateur Scientist, The, by W. Stephen Thomas, 653.  
 American Butterflies and Moths, by Cecile Hulse Matschat, 239.  
 American Geometrid Moths of the Subfamily Ennominae Heretofore Associated With or Closely Related to *Ellopia Treitschke*, some, by Hahn W. Capps, 220.  
 Anomalini of Eastern North America with Descriptions of the Larvae and a Key to Species (Coleoptera, Scarabaeidae), The, by P. O. Ritcher, 545.  
 Applied Entomology, Introduction to, by William J. Baerg, 140.  
 Biochemistry and Morphogenesis, by Joseph Needham, 36.  
 Biologia Symposia, Vol. VIII, Levels of Integration in Biological and Social Systems, edited by Jacques Cattell, 142.  
 Biology and Control of Common Blister Beetles in Arkansas, by William R. Horsfall, 792.  
 Biology: The Science of Life, by Mary Stuart MacDougall in collaboration with Robert Hegner, 797.  
 Biophysics, An Introduction to, by Otto Stuhlman, Jr., 796.  
 Brain of *Drosophila melanogaster*, The, by Maxwell E. Power, 431.  
 Carnivorous Plants, The, by Francis Ernest Lloyd, 796.  
 Catalogue of the Hemiptera, General, by W. E. China, General Editor, H. M. Parshley, Managing Editor, 545.  
 Conotrachelus Dejean (Coleoptera, Curculionidae) in the North Central United States, The Genus, by Herbert Frederick Schoof, 142.  
 Crayfishes of Florida, The, by Horton H. Hobbs, Jr., 258.

Criteria for Vertebrate Subspecies, Species, and Genera (A Symposium), by Charles M. Bogert, W. Frank Blair, Emmett Reid Dunn, E. Raymond Hall, Carl L. Hubbs, Ernst Mayr, and George Gaylord Simpson, 795.  
 Dermestidae (Larder, Hide, and Carpet Beetles) Based on Larval Characters, with a Key to the North American Genera, Classification of the, by Bryant E. Rees, 545.  
 Diptera of Connecticut, The. Guide to the Insects of Connecticut, Part IV, First Fascicle. External Morphology; Key to Families; Tanyderidae, Ptychopteridae, Trichoceridae, Anisopodidae, Tipulidae, by Guy C. Crampton, Charles H. Curran, Charles P. Alexander, and Roger B. Friend, 794.  
 Dorilaidae (Pipunculidae), A Revision of Nearctic, by D. Elmo Hardy, 792.  
 Ducks, Geese, and Swans of North America, The, by Francis H. Kortright, 194.  
 Earth and Man—a Human Geography, The, by Darrell Haug Davis, 514.  
 Ecological Crop Geography, by Karl H. W. Klages, 485.  
 Ecology of the Orthoptera and Dermaptera of the George Reserve, Michigan, The, by Irving J. Cantrall, 482.  
 Economic Entomology for South India, Handbook of, by T. V. Ramakrishna Ayyar, 242.  
 Elements of Statistics, The, by Elmer B. Mode, 280.  
 Entomologia Agricola del Peru, by Johannes E. Wille, 640.  
 Entomology, Applied, Introduction to, by William J. Baerg, 140.  
 Entomology, Outlines of, by A. D. Imms, 138.  
 Erythrodiplax (Odonata), A Revision of the Libelluline Genus, by Donald J. Borror, 587.  
 Experimental Embryology, A Manual of, by Viktor Hamburger, 364.  
 Feeding Apparatus of Biting and Disease-carrying Flies: A Wartime Contribution to Medical Entomology, The, by R. E. Snodgrass, 588.  
 Fieldbook of Native Illinois Shrubs, by Leo R. Tehon, 143.  
 Fleas of North America, The, by H. E. Ewing and Irving Fox, 336.  
 Genetics of *Drosophila*, Studies in the, III; The Drosophilidae of the Southwest, by J. T. Patterson, 454.  
 Growth and Form, On, by D'Arcy Westworth Thompson, 140.

## BOOK NOTICES, BOOKS—(Continued).

- Handbook of Economic Entomology for South India, by T. V. Ramakrishna Ayyar, 242.
- Hemlock Mortality in Northern Michigan, Causes of, by Samuel A. Graham, 680.
- Host Plants of the Leafhoppers of the Genus *Empoasca*, Studies on, by F. W. Poos and Nancy H. Wheeler, 655.
- Indiana Lakes and Streams, Investigations of, published by Indiana Dept. Conservation and Dept. Zoology, Indiana University, 624.
- Insectos do Brasil, Vol. 4, Panorpatos, Suctorios (Pulgas), Neuropteros, Trichopteros, by A. da Costa Lima, 762.
- Internal Anatomy of *Dermacentor andersoni* Stiles, The, by J. R. Douglas, 601.
- John Ray, Naturalist, His Life and Works, by Charles E. Raven, 586.
- Leafhoppers of Minnesota (Homoptera: Cicadellidae), The, by John T. Medler, 536.
- Libelluline Genus *Erythrodiplax* (Odonata), A Revision of the, by Donald J. Borror, 587.
- Literature of the Zoological Sciences, Guide to the, by Roger C. Smith, 141.
- Medical Diseases in Tropical and Sub-tropical Areas, by Chemical Publishing Co., Inc., 45.
- Medical Parasitology, by James T. Culbertson, 189.
- Microscope and Its Use, The, by Frank J. Munoz and Harry A. Charipper, 382.
- Musculature of the Labrum, Labium, and Pharyngeal Region of Adult and Immature Coleoptera, The, by Carl Kester Dorsey, 143.
- Naturalist at Large, by Thomas Barbour, 793.
- Nearctic Species of Parasitic Flies Belonging to Zenillia and Allied Genera, The, by Wendell F. Sellers, 191.
- Neotropical Pselaphidae, A Study in, by Orlando Park, 33.
- New Species of American Spiders, A Hundred, by Ralph V. Chamberlin and Wilton Ivie, 318.
- North American Species of Buprestid Beetles Belonging to the Tribe Chrysobothrini, A Revision of the, by W. S. Fisher, 309.
- On Your Own, by Samuel A. Graham and Earl C. O'Roke, 500.
- Outlines of Entomology, by A. D. Imms, 138.
- Parasitology, Introduction to, by A. S. Pearse, 140.
- Parasitology, Medical, by James T. Culbertson, 189.
- Phyllophaga (Coleoptera: Scarabaeidae), A Classification of the Larvae and Adults of the Genus, by Adam G. Böving, 618.
- Portraits of Kentuckians, by W. D. Funkhouser, 793.
- Preparation and Preservation of Insects, On the, by J. Manson Valentine, 139.
- Promethea Moth, The Tale of the, by Henry B. Kane, 143.
- Psyllids of America North of Mexico (Psyllidae: Homoptera), The, by Leonard D. Tuthill, 739.
- Revision of the Libelluline Genus *Erythrodiplax* (Odonata), A, by Donald J. Borror, 587.
- Revision of the genus *Phlocosinus* Chapuis in North America (Coleoptera, Scotylidae), by M. W. Blackman, 220.
- Revision of Nearctic Dorilaidae (Pipunculidae), A, by D. Elmo Hardy, 792.
- Shelter Trees in War and Peace, by Ephraim Porter Felt, 359.
- Siphonaptera: Species and Host List of Montana Fleas, by William L. Jellison, Glen M. Kohls, and Harlow B. Mills, 424.
- South American Weevils of the Genus *Conotrachelus*, Monograph of, by Karl Fiedler, 127.
- Spiders, A Hundred New Species of American, by Ralph V. Chamberlin and Wilton Ivie, 318.
- Stoneflies of Southwestern British Columbia, by William E. Ricker, 536.
- Straight and Crooked Thinking, by Robert H. Thouless, 139.
- Systematics and the Origin of Species, by Ernst Mayr, 138.
- Thynnindes Chiles, Die, by Leonidas Durán-Moya, 792.
- Trombidiidae en Colombia, Veinticinco Especies Neuvas de, by Jorge Boshell and J. A. Kerr, 793.
- Type Species of the Genera and Subgenera of Bees, The, by Grace Sandhouse, 220.
- Virus Diseases, by members of the Rockefeller Institute for Medical Research: Thomas M. Rivers, Wendell M. Stanley, Louis O. Kunkel, Richard E. Shope, Frank L. Horsfall, Jr., and Peyton Rous, 646.
- West Indian Beetles of the Family Staphylinidae, Monograph of, by Richard E. Blackwelder, 249.

- Brachypogon, 780.  
 Brimley, C. S. Article by, 128.  
 Brown, F. M. Article by, 87.  
 Brues, C. T. Article by, 310.  
 Butterflies, Ecuadorian, of the genus  
     Lymanopoda, 87.  
*Caeculus peltiti*, a new species of mite  
     from Virginia, 389.  
 Calyptopogon, 782.  
 Campylocentrus brevicornis, 481.  
     curvidens, 481.  
     hamifer, 481.  
     vitreipennis, 481.  
*Carinolimulodes*, 574.  
 Carpet beetles, some vitamin require-  
     ments of, 483.  
 Causey, O. R. Article by, 11.  
 Cellulose fermentation by termite  
     protozoa, 730.  
*Centris lanipes*, 646.  
 Centrotinae, 481.  
*Cephaloplectodes*, 573.  
*Cephaloplectus*, 579.  
     argentinus, 581.  
     flavus, 582.  
     godmani, 580.  
     mus, 581.  
     trilobitoides, 583.  
*Ceratobezzia*, 784.  
     flavida, 761.  
 Ceratopogon, 780.  
 Ceratopogonidae of the Americas,  
     generic synopsis of, a bibliography,  
     and a list of the North American  
     species, 763.  
 Ceratopogonidae, key to North and  
     South American genera of, 768.  
     list of North American species of, 776.  
     two new species of, 761.  
*Ceresa nigrovittata*, 471.  
     rubra, 471.  
     testacea, 471.  
     viridilineata, 472.  
     vitulus, 471.  
 Ceresini, 471.  
*Chalybion zimmermanni*, 648.  
 Chamberlin, J. C. Article by, 486.  
*Chaoborus astictopus*, 383.  
*Cheliomyrmex*, 320.  
     megalonyx, 320.  
*Cheliomyrmicini*, 320.  
*Chelostomoides*, 664.  
*Chlorion*, a new species of from Cuba,  
     238.  
*Chlorion harrisi*, 648.  
*Chlorion* (Isodontia) *bruneri*, 238.  
     costipennis, 648.  
*Chrysis* (Trichrysis) *parvula*, 652.  
     sp., 652.  
*Chrysobothris*, two new, 34.  
     crandalli, 34.  
     culbertsoniana, 34.  
*Chrysosarus*, 664.  
*Clinohoelea*, 783.  
 Cockroach egg-case deposition, 221.  
*Cophura*, revision of the genus, 281.  
*Cophura*, 283.  
     *acapulcae*, 302.  
     albasetosa, 308.  
     Albasetosa group, 307.  
     ameles, 298.  
     apolda, 301.  
     arizonensis, 299.  
     atypha, 301.  
     bella, 291.  
     Bella group, 291.  
     brevicornis, 306.  
     Brevicornis group, 306.  
     brevicornis melanochaeta, 306.  
     caca, 306.  
     calla, 303.  
     clausa, 296.  
     cora, 299.  
     daphne, 290.  
     dora, 296.  
     fur, 297.  
     Fur group, 296.  
     hesperia, 304.  
     humilis, 289.  
     igualae, 300.  
     lutzi, 305.  
     lutzi wilcoxi, 305.  
     melanochaeta, 306.  
     nephressa, 292.  
     painteri, 293.  
     Painteri group, 292.  
     pollinosa, 304.  
     pulchella, 297.  
     scitula, 307.  
     sculleni, 291.  
     Sculleni group, 290.  
     sodalis, 289.  
     Sodalis group, 288.  
     stylosa, 304.  
     sundra, 295.  
     texana, 298.  
     trunca, 294.  
     Trunca group, 293.  
     vera, 305.  
     vitripennis, 308.  
     wilcoxi, 305.  
     willistoni, 290.  
     zandra, 294.  
 Corrections (errors and omissions), 798.  
 Cotton in central Texas, Araneida  
     found on, 257.  
 Crane-flies from South America, new  
     species of, 103.  
*Crepidodhamma*, 507.  
     bicolor, 508.  
     cinctipes, 509.  
     pseudocinctipes, 510.  
*Crepinia*, 786.  
*Cressoniella*, 662.  
 Crowell, H. H. Article by, 243.  
*Culicoides*, 779.  
 Cycles, foundation for the study of, 335.



- Cyclophleps*, 375.  
*tenebrifera*, 375.  
*Cymbomorpha prasina*, 468.  
*Cyphonia clavata*, 472.  
*Dactylomegachile*, 670.  
*Darninae*, 465.  
*Darnis lateralis*, 468.  
*Darnoides affinis*, 468.  
*Dasyhelea*, 778.  
*Dasymegachile*, 669.  
 Davidson, R. H. Article by, 636.  
 Day, M. F. Article by, 1.  
 Deane, L. M. Article by, 11.  
 Deane, M. P. Article by, 11.  
 DeLong, D. M. Articles by, 448, 636, 654.  
 Deonier, C. C. Article by, 383.  
 Dermatobia, mosquitoes as vectors of in eastern Colombia, 21.  
*Diaphanobezzia*, 781.  
*Dibezzia*, 786.  
*Diceratomia azteca*, 645.  
*Dicranophora*, 371.  
   *affinis*, 373.  
   *astuta*, 372.  
   *brevifurca*, 371.  
   *furcifera*, 372.  
   *picta*, 373.  
*Dicrobezzia*, 785.  
*Dicrohelea*, 783.  
 Dimorphism in the female honeybee: development of the metathoracic tibia, 227.  
*Diplosella*, 780.  
*Dolicholelea*, 777.  
*Dorylinae*, 319.  
   key to genera of larvae, 320.  
*Dorylini*, 321.  
*Dorylus* (*Anomma*), 321.  
   *nigricans molesta*, 322.  
   *wilverthi*, 321.  
*Dorylus* (*Dorylus*) *affinis*, 324.  
 Dow, Richard. Article by, 240.  
 Dragonfly nymph design on Indian pottery, 190.  
 Dybas, Henry S. Article by, 546.  
*Echinohelea*, 783.  
*Ecitolimulodes*, 575.  
*Eciton* (*Acamatus*) *pilosum*, 331.  
   *schmitti*, 331.  
*Eciton* (*Eciton*) *burchelli*, 328.  
   *hamatum*, 327.  
   *quadriglume dulcius jujuyensis*, 331.  
   *vagans*, 331.  
*Eciton* (*Labidus*) *coecum*, 332.  
*Ecitonini*, 324.  
 Ecuador, a new genus and new species of Syrphidae from, 425.  
 Ecuadorian butterflies of the genus *Lymanopoda*, notes on, 87.  
 Egg-case deposition by cockroaches, 221.  
*Elasmocorinae*, 612.  
*Elasmocoris*, 613.  
   *setigerus*, 614.  
*Elephantomyia*, 121.  
   *primitiva*, 121.  
*Empoasca*, studies of the genus, 636.  
*Empoasca cothurna*, 639.  
   *diacumanis*, 638.  
   *irrita*, 636.  
   *quintapunctata*, 638.  
   *lectona*, 639.  
   *tripunctata*, 636.  
*Enchenopa ansera*, 456.  
   *bifusifera*, 456.  
   *quadricolor*, 456.  
*Enchophyllum albidum*, 457.  
   *dubium*, 457.  
   *melaleucum*, 457.  
*Endoiastus caviceps*, 481.  
*Entaphius funebris*, 468.  
*Entylia gemmata*, 478.  
   *sinuata*, 479.  
*Erechtia sallaei*, 457.  
*Ereosmia*, 66.  
*Erythrosmia*, 85.  
*Euforcipomyia*, 778.  
*Eukraiohelea*, 781.  
*Eulimulodes*, 584.  
   *mexicanus*, 585.  
*Eumeniid* wasps, 533.  
*Euritea munda*, 472.  
*Eusimulium*, 264.  
   *aureum*, 266.  
   *borealis*, 268.  
   *canonicolum*, 270.  
   *clarum*, 266.  
   *dacotense*, 268.  
   *johannseni*, 270.  
   *minus*, 266.  
   *mutatum permutatum*, 268.  
   *obtusum*, 270.  
   *osborni*, 271.  
   *pecuarum*, 270.  
   *permutatum*, 268.  
   *pugetense*, 271.  
   *quadratus*, 271.  
*Eutrichareae*, 671.  
*Exoprosopa capucina*, 652.  
*Exoskeleton* and musculature of the abdomen of *Grylloblatta campodeiformis*, 681.  
 False scorpion genus *Synsphyronus*, the taxonomy of, 486.  
*Fanthamia*, 780.  
*Feaelloidea*, 486.  
 Female reproductive organs of *Habrobracon juglandis*, anatomy and histology of, 537.  
 Fernald, H. T. Article by, 238.  
 Fluke, C. L. Article by, 425.

- Food passage through the gut of the southern armyworm, 243.  
 Forbes, W. T. M. Article by, 707.  
 Forcipomyia, 777.  
 Foundation for the study of cycles, 335.  
 Fox, Henry. Article by, 25.  
 Funkhouser, W. D. Article by, 455.
- Garypidae, 488.  
 Garypinae, 488.  
 Garypoidea, 486, 488.  
 Geijskes, D. C. Article by, 165.  
 Genitalia, male, of certain Isodontia, 240.  
*Glossosmia*, 84.  
*Gnamptocentrus cavipennis*, 481.  
*sinuatus*, 481.  
 Gnat, Clear Lake, biology of the immature stages of, 383.  
*Grandolobus vittatipennis*, 477.  
*Gronoceras*, 671.  
*Grylloblatta campodeiformis*, on the anatomy of, 681.  
 Guatemala, Membracidae of, 455.  
 Gurney, A. B. Article by, 195.
- Haasiella, 783.  
*Habrobracon juglandis*, anatomy and histology of the female reproductive organs of, 537.  
*Hadronotus ajax*, a parasite in the eggs of the squash-bug, the biology of, 625.  
*Halictophagus*, new species of, with a key to the genus in North America, 341.  
*Halictophagus*, list of exotic species of, 353.  
 key to American species of, 342.  
*Halictophagus*, 341.  
*acutus*, 352.  
*americanus*, 344.  
*australensis*, 353.  
*barberi*, 350.  
*bidentatus*, 351.  
*callosus*, 350.  
*chinensis*, 357.  
*cladoceras*, 353.  
*compactus*, 355.  
*curtisii*, 353.  
*fulmeki*, 355.  
*gressitti*, 357.  
*indicus*, 356.  
*insidiator*, 355.  
*insularum*, 344.  
*jacobsoni*, 354.  
*javanensis*, 355.  
*mackayi*, 350.  
*membraciphaga*, 355.  
*obtusae*, 346.  
*omani*, 345.  
*oncometopiae*, 348.  
*orientalis*, 359.  
*paradeniya*, 354.  
*phaeodes*, 353.  
*piperi*, 358.  
*schwarzi*, 359.  
*schwarzii*, 354.  
*setratus*, 351.  
*stenodes*, 354.  
*tryoni*, 354.  
*uhleri*, 348.
- Headley, A. E. Article by, 743.  
*Hebeticoides acutus*, 468.  
 Hesperoid genera, types of, 754.  
*Hetaerina dominula*, 168.  
*moribunda*, 171.  
 sp., 171.  
*Heteromyia*, 783.  
*Heteronotus trinodosus*, 468.  
 Hexagenia nymphs, swimming and burrowing activities of, 250.  
*Hexosmia*, 74.  
*Histiiodroma*, 373.  
*fascipennis*, 373.  
*flaveola*, 374.  
*inermis*, 374.  
*tricolor*, 374, 798.  
*Histiiodroma tricolor*, 374, 798.  
*Holoconops*, 776.  
*Homobezzia*, 785.  
*Homohalea*, 784.  
 Honeybee: development of the metathoracic tibia; dimorphism in the female, 227.  
 Hoplistes, 377.  
*bispinosus*, 378.  
 Hoplophorinae, 459.  
*Hoplosmia*, 86.  
 Horsfall, W. R. Article by, 41.  
 Hungate, R. E. Article by, 730.  
 Huntington, Ellsworth. Notice by, 335.  
*Hyphinoe asphaltina*, 468.  
*bigutta*, 469.  
*cuneata*, 469.  
*marginalis*, 469.  
*ochracea*, 469.  
*purulensis*, 469.  
*tau*, 469.
- Hypsoprora coronata*, 457.  
*ningerrima*, 458.
- Idiogarypus*, 499.  
*hansenii*, 500.  
*Idiolimulodes*, 572.  
 Indian pottery, a dragonfly nymph design on, 190.  
 Isodontia, note on the male genitalia of, 240.  
 Isodontia, see Chlorion.  
*Isohelea*, 780.  
*Isthmohelea*, 781.
- James, M. T. Articles by, 365, 380.  
*Jenkinshalea*, 783.  
 Johannsen, O. A. Articles by, 761, 763.  
*Johannsenomyia*, 784.

- Kagan, Martin. Article by, 257.  
 Kennedy, C. H. Article by, 190.  
 Kiefferomyia, 782.  
 Knowlton, G. F. Article by, 259.  
 Knull, J. N. Article by, 34.  
 Krombein, K. V. Article by, 451.
- Lampyridae, the isolation of a red-fluorescent pigment, lampyrine, from, 37.  
 Lampyrine, isolation of from the Lampyridae, 37.  
 Larva and systematic position of the meloid genus *Poreospasta*, 360.  
 Larva of the wasp *Polistes gallicus*, gross anatomy of, 619.  
 Lasiobezzia, 784.  
 Lasiöhelea, 777.  
 Leafhoppers, a new genus and species of from Mexico, 448, 654.  
 Lepidohelea, 778.  
 Leptoconops, 776.  
 Leptorachis, 663.  
 Leptothorax longispinosus and *L. curvispinosus*, population studies of, 743.  
*Leucopitilum*, 380.  
   *bassleri*, 382.  
   *plaumanni*, 380.  
*Leucospis* sp., 652.  
 Life History of *Scirtes orbiculatus*, 672.  
 Life history of *Trichodes ornatus*, a larval predator in the nests of bees and wasps, observations on, 589.  
*Limnophila*, 120.  
   *pergracilis*, 120.  
*Limonia*, 107.  
*Limonia* (Dicranomyia) *perdistalis*, 208.  
*Limonia* (Geranomyia) *assueta*, 111.  
   *hirsutinota*, 114.  
   *nugatoria*, 112.  
   *subpenteres*, 113.  
*Limonia* (*Limonia*) *subrecticulata*, 107.  
*Limonia* (*Neolimnobia*) *pugilis*, 110.  
*Limonia* (*Rhipidia*) *polyclada*, 115.  
   *sprucei*, 117.  
*Limulodes*, 567.  
   *argentinus*, 577.  
   *elongatus*, 578.  
   *heyeri*, 577.  
   *mexicanus*, 577.  
   *tibialis*, 578.  
*Limulodes* (*Carinolimulodes*), 574.  
   *brachyscelis*, 574.  
   *philovagans*, 575.  
*Limulodes* (*Cephaloplectodes*), 573.  
   *pallidus*, 573.  
*Limulodes* (*Ecitolimulodes*), 575.  
   *bolivianus*, 576.  
   *manni*, 576.  
   *stenotropis*, 575.  
*Limulodes* (*Idiolimulodes*), 572.  
   *navajo*, 572.
- Limulodes* (*Limulodes*), 568.  
   *paradoxus*, 568.  
*Limulodes* (*Neolimulodes*), 570.  
   *parki*, 570.  
*Limulodidae* (Coleoptera): a new family proposed for myrmecophiles of the subfamilies *Limulodinae* (Ptiliidae) and *Cephaloplectinae* (Staphylinidae), a synopsis of, 546.  
*Limulodidae*, 564.  
   ecology of, 561.  
   key to the genera of, 567.  
   morphology of, 548.  
 Lindsey list, 1925, additions and corrections to, 754.  
 Linsley, E. G. Article by, 589.  
*Litomegachile*, 662.  
*Loewimyia*, 503.  
   *bifurcata*, 504.  
*Luciomyia*, 782.  
 Lyman, F. Earle. Article by, 250.  
*Lymanopoda*, notes on the genus, 187.  
*Lymanopoda*, 87.  
   *acraeida*, 102.  
   *Acraeida* group, 101.  
   *albocincta*, 100.  
   *altis*, 99.  
   *Cinna* group, 95.  
   *confusa*, 89.  
   *eubagioides*, 91.  
   *ferruginosa*, 98.  
   *hazelana*, 89.  
   *labda*, 96.  
   *Labda* group, 96.  
   *Lactea* group, 90.  
   *nivea melea*, 92.  
   *nivea nivea*, 91.  
   *obsoleta*, 98.  
   *Obsoleta* group, 98.  
   *panacea*, 101.  
   *samius*, 88.  
   *Samius* group, 88.  
 Lysozus, 371.  
   *columbianus*, 371.
- Macropeza*, 782.  
*Macroptilum*, 783.  
*Macrosaigon* sp., probably *excavatum*, 652.  
*Macruöhelea*, 782.  
 MacSwain, J. W. Articles by, 360, 589.  
 Malarial mosquito, some responses of to light, 41.  
 Mantid oothecae, studies on, 25.  
*Maorigarypus*, 496.  
 Mayfly nymphs of the genus *Hexagenia*, swimming and burrowing activities of, 250.  
*Megacanthopus imitator*, 720.  
*Megachile*, on the classification of neotropical, 656.  
*Megachile*, key to neotropical subgenera of, 658.

- Megachile exilis*, 645.  
*florensis*, 671.  
*peruviana*, 644.  
*Megachile* (*Chrysosarus*) *congruata*, 666.  
*Megachile* (*Pseudocentron*) *cordialis*, 664.  
 Melampy, R. M. Article by, 227.  
*Melanosarus*, 663.  
 Meloid genus *Poreospasta*, the primary larva and systematic position of, 360.  
 Members of the Entomological Society of America enrolled in the armed and related services of the United States, 337.  
 Membracidae of Guatemala, 455.  
 Membracinae, 455.  
*Membracis foliata*, 458.  
*mexicana*, 458.  
*Metahelea*, 786.  
 Metamorphosis of the nervous system of *Aedes dorsalis*, 432.  
*Metapolybia cingulata*, 516.  
 Metcalf, R. L. Article by, 37.  
*Metcalfiella cinerea*, 459.  
*disparipes*, 459.  
*monogramma*, 460.  
 Mexican insects, list of papers on, 653.  
 Mexican leafhoppers, a new genus and species of, 448, 654.  
 Mexican social and solitary bees, nesting habits of, 641.  
 Mexican social and solitary wasps of the family Vespidae, nesting habits of, 515.  
 Mexican sphecids, nesting habits of, with notes on their parasites, 647.  
 Michener, C. D. Article by, 49.  
 Micrathyria, life history notes on, 185.  
*Micrathyria*, 185.  
*aequalis*, 187.  
*didyma*, 188.  
*hageni*, 185.  
*Microcentrus pileatus*, 481.  
*proximus*, 481.  
*Microconops*, 776.  
*Microtalis balteata*, 474.  
*ephippium*, 474.  
*lugubrina*, 474.  
*Mischocyttarus ater*, *Polybia atra*, and their relatives, 717.  
*Mischocyttarus angulatus ictezicus*, 531.  
*ater*, 529.  
*ater uniformis*, 721.  
*basimaculata*, 530.  
*cubensis mexicanus*, 531.  
*ictezicus*, 531.  
*immarginatus*, 531.  
*labiatus*, 529.  
*mexicanus*, 531.  
*pallidipectus*, 529.  
*socialis*, 721.  
*socialis uniformis*, 722.  
*Mischocyttarus* wasps, 528.  
 Mitchell, T. B. Article by, 656.  
 Mite, a new species of from Virginia, 389.  
*Molophilus*, 126.  
*Molophilus* (*Molophilus*) *debiliior*, 126.  
*Monohalea*, 781.  
 Moore, Warren. Article by, 483.  
 Morphological characters, sporadic loss of stability in, in the false scorpion genus *Synsphyronus*, 486.  
 Mosquito from Ceara, Brazil, *Anopheles* (*Nyssorhynchus*) *sawyeri*, a new anopheline, 11.  
 Mosquito, malarial, some responses of to light, 41.  
 Mosquitoes as vectors of *Dermatobia* in eastern Colombia, 21.  
 Musculature of the abdomen of *Grylloblatta campodeiformis*, 681.  
 Myrmecophiles of the subfamilies *Limulodinae* (*Ptiliidae*) and *Cephaloplectinae* (*Staphylinidae*), synopsis of, 546.  
*Neanalcocerus*, 370.  
*hortulanus*, 370.  
 Needham, J. G. Article by, 185.  
*Neolimulodes*, 570.  
*Neomegachile*, 662.  
 Neotropical *Megachile*, on the classification of, 656.  
 Neotropical *Stratiomyidae*, studies in, 365, 380.  
 Nervous system of *Aedes dorsalis*, metamorphosis of, 432.  
 Nesting habits of certain social and solitary bees of Mexico, notes on, 641.  
 Nesting habits of Mexican social and solitary wasps of the family Vespidae, 515.  
 Nesting habits of certain sphecids wasps of Mexico, with notes on their parasites, 647.  
 Nests of *Vespula*, 740.  
*Neurohelea*, 783.  
 Nevin, F. Reese. Article by, 389.  
*Nilobezzia*, 786.  
 Nippononysson, a new Philippine, 451.  
 Nippononysson *adiaphilus*, 451.  
 Nomenclature, zoological, general council on, 333.  
*Nomia nortoni*, 645.  
*Notocera bituberculata*, 458.  
*cerviceps*, 458.  
*hispidia*, 458.  
*Nyssorhynchus*, 11, 192.  
*Nyssorhynchus* complex, 192.  
 Odonata of Surinam, notes on, 165.  
 Odoriferous glands of *Tribolium confusum*, 397.

- Odynerus hidalgo*, 533.  
*pratensis*, 533.  
*verus*, 533.  
 Oothecae of introduced Asiatic man-  
 tids, further studies on, 25.  
*Ophiderma mus*, 477.  
*Orimarga*, 118.  
*Orimarga* (*Orimarga*) *chionopus*, 119.  
*saturnina*, 118.  
 Osburn, R. C. Article by, 740.  
 Osgood, W. H. Notice by, 333.  
*Othinosmia*, 86.  
*Oxyhelea*, 780.  
*Oxystigma petiolatum*, 165.  
  
*Pachodynerus nasidens*, 533.  
*Palonica satyrus*, 475.  
*Palpomyia*, 784.  
 Panama, a new species of *Polybia*  
 from, 394.  
*Parabezzia*, 782.  
*Paralimulodes*, 578.  
*Parantonae dipteroides*, 474.  
*Paraphoconus*, 782.  
*Parasimulium*, 260.  
*furcatum*, 260.  
 Parker, H. L. Article by, 619.  
*Parrotia*, 785.  
*Passaloecus pusillus*, 648.  
*Pellucidomyia*, 782.  
*Phaeosmia*, 77.  
*Philya minor*, 458.  
*Phlebosotera*, 510.  
*setipalpis*, 511.  
 Pigment, lampyrine, from the Lam-  
 pyridae, the isolation of, 37.  
 Pitcher plants, insect inquilines and  
 victims of, 128.  
*Platycotis discreta*, 460.  
*histrionica*, 460.  
*nigrorufa*, 460.  
*Podium irridesceus*, 648.  
*Polistes gallicus*, gross anatomy of the  
 larva of, 619.  
*Polistes canadensis*, 524.  
*carnifex*, 521.  
*exclamans*, 525.  
*fuscatus apachus*, 522.  
*ignobilis*, 717.  
*instabilis*, 524.  
*major*, 522.  
*pacificus modestus*, 522.  
*Polistes* wasps, 521.  
*Polybia atra*, *Mischocyttarus ater*, and  
 their relatives, 717.  
*Polybia*, a new species of from Panama,  
 394.  
*Polybia atra*, 718.  
*barbouri*, 394.  
*ignobilis*, 723.  
*nigra*, 719.  
*occidentalis*, 517.  
*raui*, 727.  
*rufitarsis*, 728.  
*rufitarsis peruviana*, 729.  
*simillima*, 726.  
*socialis*, 719.  
*tinctipennis*, 727.  
*tinctipennis nebulosa*, 728.  
*Polybia* wasps, 516.  
*Polyglypta costata*, 479.  
*dorsalis*, 479.  
*lineata*, 479.  
*nigella*, 479.  
*nigridorsis*, 479.  
*Polyglyptini*, 477.  
*Polyglyptodes cucullatus*, 480.  
*scaphiformis*, 480.  
*Poppea affinis*, 474.  
*rectispina*, 474.  
*reticulata*, 474.  
*subrugosa*, 474.  
*torva*, 474.  
 Population studies of two species of  
 ants, *Leptothorax longispinosus* and  
*L. curvispinosus*, 743.  
*Poreospasta*, the primary larva and  
 systematic position of, 360.  
*Potnia brunneifrons*, 464.  
*maculata*, 463.  
 Power, M. E. Article by, 227.  
*Prionoglaris*, 202.  
 mouthparts of, 216.  
 Pritchard, A. E. Article by, 281.  
*Probezzia*, 785.  
*Procyrtia intectus*, 469.  
*Prosimulium*, 260.  
*dicentum*, 263.  
*dicum*, 262.  
*exigens*, 262.  
*flaviantennatus*, 262.  
*fulvum*, 261.  
*novum*, 261.  
*onychodactylum*, 261.  
*pancerastes*, 263.  
*pleurale*, 263.  
*unicum*, 262.  
*Pseudobezzia*, 782.  
*Pseudocentron*, 663.  
*Psocids* of the tribe *psyllipsocini*,  
 synopsis of, 195.  
*Psyllipsocini*, key to genera of, 196.  
*Psyllipsocus*, 203.  
*oculatus*, 214.  
*ramburii*, 206.  
*yucatan*, 212.  
*Pterobosca*, 777.  
*Philosarus*, 667.  
  
 Rau, Phil. Articles by, 221, 515, 641,  
 647.  
*Reduvioidea*, a revised classification  
 of, with a new subfamily from  
 South America, 602.  
*Reduvioidea*, 607.  
 key to families and subfamilies of, 610.

- Rhaphiocera, 378.  
   *armata*, 379.  
   *hoplistes*, 379.  
   *ornata*, 378.  
   *sancti-pauli*, 379.  
 Rhaphiocerinae, classification of, 365.  
 Rhingia *longirostris*, 430.  
 Rhinopsis, 46.  
 Rhodosmia, 85.  
 Rhopalosoma, the American species of, 310.  
 Rhopalosoma, 312.  
   *aenigmaticum*, 315.  
   *bolivianum*, 316.  
   *nearcticum*, 316.  
   *poeyi*, 315.  
   *simile*, 317.  
 Riley Centennial Exhibition, notice of, 447.  
 Ring gland of Diptera Brachycera, the homologies of, 1.  
 Rodwayia, 578.  
 Roth, Louis M. Article by, 397.  
  
 Sabrosky, C. W. Article by, 501.  
 Sampaio, M. M. Article by, 11.  
 Sarracenia flava, insects found in, 128.  
 Sarracenia purpurea, insects found in, 133.  
 Sarracenia rubra, insects found in, 134.  
 Sayapis, 664.  
 Scalmorphus reticulatus, 458.  
 Schell, S. C. Article by, 625.  
 Schizohalea, 782.  
 Sceliphron assimile, 647.  
 Scirtes orbiculatus, life history, of, 672.  
 Seevers, C. H. Article by, 546.  
 Senotainia sp., 652.  
 Serromyia, 781.  
 Shepard, H. H. Article by, 754.  
 Simuliidae of western United States, a taxonomic and distributional study of, 259.  
 Simulium, 272.  
   *arcticum*, 276.  
   *beameri*, 279.  
   *bivittatum*, 278.  
   *canadense*, 276.  
   *decorum*, 275.  
   *griseum*, 278.  
   *hunteri*, 275.  
   *jacumbae*, 276.  
   *kamloopsi*, 274.  
   *knowltoni*, 277.  
   *mediovittatum*, 279.  
   *notatum*, 278.  
   *occidentale*, 273.  
   *piperi*, 280.  
   *sayi*, 275.  
   *stonei*, 277.  
   *trivittatum*, 279.  
   *vandalicum*, 277.  
   *venustum*, 275.  
   *virgatum*, 274.  
   *vittatum*, 274.  
 Smerdalea horrescens, 482.  
 Smilliinae, 470.  
 Smilliini, 475.  
 South America, new species of crane-flies from, 103.  
 Speleketor, 197.  
   *flocki*, 197.  
   mouthparts of, 216.  
 Sphaeromias, 784.  
 Sphecid wasps of Mexico, nesting habits of, with notes on their parasites, 647.  
 Spongophorus affinis, 458.  
   *ballista*, 459.  
   *championi*, 459.  
   *inflatus*, 459.  
   *robustus*, 459.  
 Spotts, J. C. Notice by, 447.  
 Squash-bug egg parasite, Hadronotus ajax, biology of, 625.  
 Stains, G. S. Article by, 259.  
 Stelis costalis, 645.  
 Stenodynerus mystecus, 534.  
 Stenomicra, 502.  
 Stenoxenus, 783.  
 Stictopelta acutula, 469.  
   *assimilis*, 469.  
   *indeterminata*, 469.  
   *stilobezzia*, 781.  
   *uncinata*, 761.  
 Stizus godmani, 648.  
 Stoneana, a new genus, and three new species, of Mexican leafhoppers, 448.  
 Stoneana, 448.  
   *balli*, 449.  
   *marthae*, 448.  
   *separatus*, 450.  
 Strandtmann, R. W. Article by, 46.  
 Stratiomyidae, studies in neotropical, 365, 380.  
 Styloconops, 776.  
 Surinam, notes on the Odonata of, 165.  
 Synsphyronus, 488, 490.  
   key to species of, 489.  
   taxonomy of, 486.  
 Synsphyronus (Maorigarypus), 496.  
   *melanochelatus*, 498.  
   *mimulus*, 496.  
   *viridis*, 498.  
 Synsphyronus (Synsphyronus), 490.  
   *mimetis*, 492.  
   *paradoxus*, 490.  
 Syrphidae from Ecuador, a new genus and new species of, 425.  
  
 Tanypremna, 104.  
 Tanypremna (Tanypremnella) *megacera*, 105.  
   *microcera*, 106.  
 Tanypremna (Pehlkea) *regulus*, 104.

- Telamonini*, 475.  
*Telebasis sanguinalis*, 177.  
*Termite* protozoa, cellulose fermentation by, 730.  
*Tetrabezzi*, 782, 786.  
*Teucholabis*, 123.  
*Teucholabis* (*Teucholabis*), 123.  
*distifurca*, 125.  
*perlata*, 124.  
*spica*, 123.  
*Thrasymedes dubia*, 475.  
*major*, 475.  
*varieta*, 475.  
*Thyridia*, the genus, 707.  
*Thyridia confusa*, 709.  
*grandior*, 714.  
*maxima*, 711.  
*mystica*, 712.  
*nigerrima*, 712.  
*singularis*, 716.  
*themisto*, 709.  
*Thyridomyia*, 778.  
Tibia of female honeybee, dimorphism in, 227.  
*Tolania obtusa*, 482.  
*opponens*, 482.  
*Tomogonia vittatipennis*, 470.  
Townsend, C. H. T. Article by, 192.  
*Tragopa testudina*, 470.  
*Tragopinae*, 470.  
*Tribolium confusum*, studies on the gaseous secretion of, 397.  
*odoriferous glands of*, 397.  
*Trichodes ornatus*, a larval predator in the nests of bees and wasps, observations on the life history of, 589.  
*Trigona mexicana*, 642.  
*pectoralis*, 642.  
*Trigona* (*Partamona*) *testacea orizabensis*, 641.  
*Trypoxylon mexicanum*, 649.  
*salti*, 649.  
*sp.*, group *fabricator*, 649.  
*sp.*, near *nitidum*, 649.  
*sp.*, near *palliditarsus*, 650.  
*tenocitlan*, 649.  
*texense*, 650.  
*Tuberculanostoma*, 425.  
*antennatum*, 426.  
*browni*, 429.  
*cilium*, 428.  
*pectinis*, 430.  
*Tylopelta gibbera*, 459.  
*Umbonia antiqua*, 462.  
*crassicornis*, 460.  
*ermanni*, 460.  
*immaculata*, 463.  
*nigrata*, 462.  
*reclinata*, 460.  
*spinosa*, 462.  
Usinger, R. L. Article by, 602.  
*Vanduzee* *albifrons*, 480.  
*mayana*, 480.  
*segmentata*, 480.  
*Vectors of Dermatobia* in eastern Colombia, mosquitoes as, 21.  
*Vespa atra*, 717.  
*Vespidae*, nesting habits of Mexican social and solitary wasps of the family, 515.  
*Vespula* nests, two unusual, 740.  
Vitamin requirements of black carpet beetles, 483.  
Walker, E. M. Article by, 681.  
Wasps (sphecids) of Mexico, the nesting habits of, with notes on their parasites, 647.  
Wheeler, G. C. Article by, 319.  
Woolley, T. A. Article by, 432.  
Wray, D. L. Article by, 128.  
*Xanthosarus*, 662.  
*Xenohelea*, 786.  
*Xeromegachile*, 662.  
*Xerosmia*, 81.  
*Xylocopa brazilianorum*, 646.  
*Zethus aztecus*, 535.  
*pipiens*, 535.  
Zoological nomenclature, general council on, 333.

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